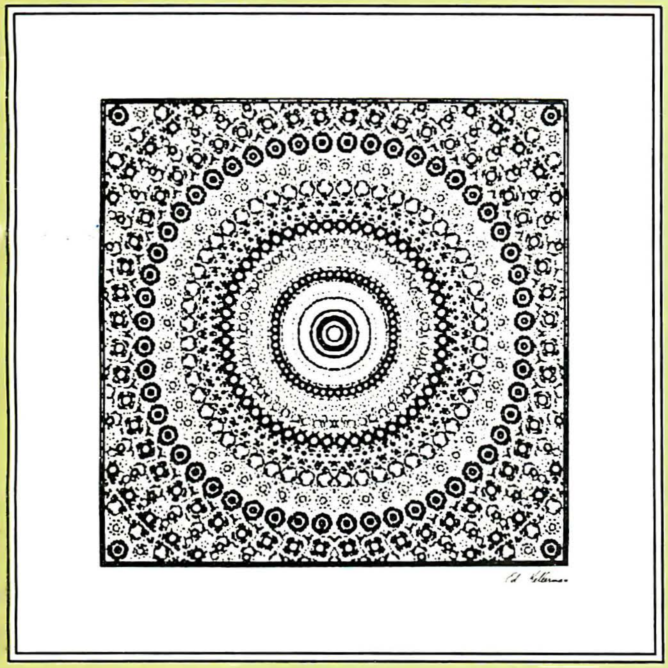
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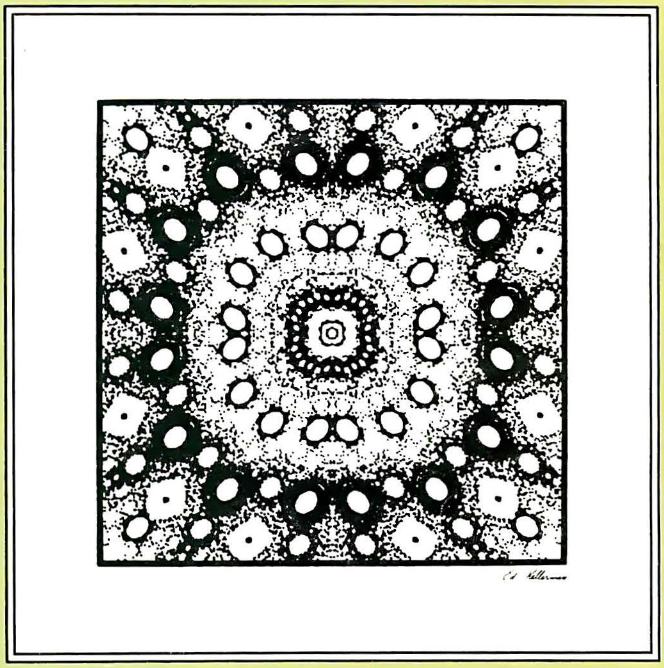
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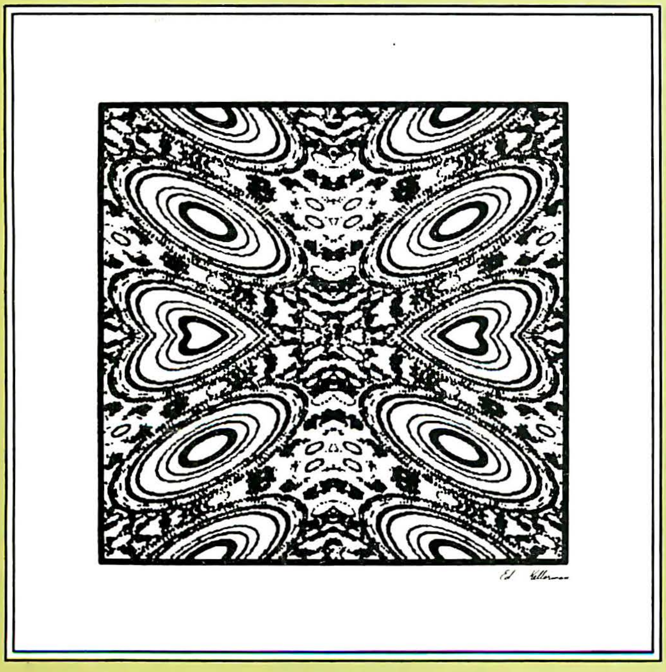
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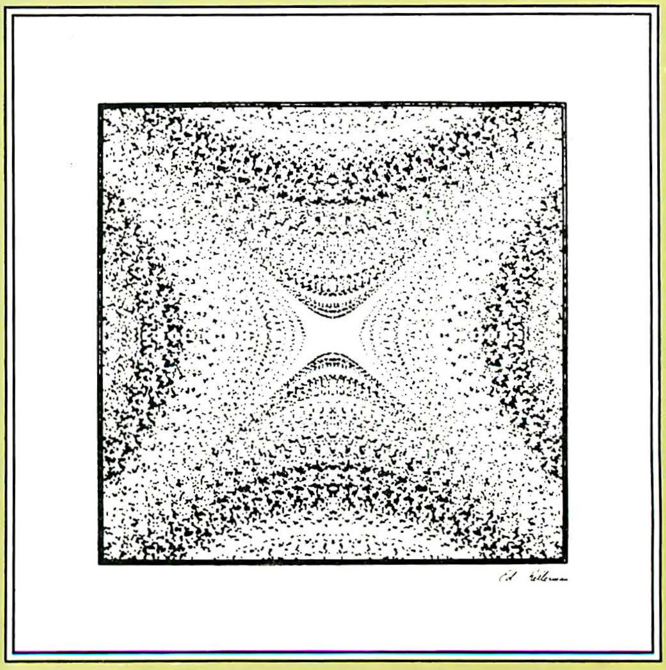
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A fast Z80 microcomputer with up to 512 kilobytes of RAM, 4 disk drives and 1 megabyte of disk storage—with CRT terminal and fast printer. Even an optional PROM programmer. Strong software support, too, like FORTRAN IV, Extended BASIC, and Macro Assembler.

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Chances are you've already heard that there is a Cromemco System Three Computer. We've proudly previewed it at WESCON on the West Coast and NYPC on the East Coast.

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And what a computer we've got for you.

It does it all.

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Further, the System Three comes with two disk drives to give you 512 kilobytes of disk storage. Soft-sectored IBM format. Optionally, you can have four drives with 1 megabyte of storage.

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21-SLOT MOTHERBOARD

This new CS-3 is a computer that won't be outdated soon. It has a 21-card-slot slide-out motherboard and an S-100 bus so that you can plug in all sorts of support circuitry. The heavy-duty 30-amp power supply can easily handle all this.

BROAD S-100 SUPPORT

The S-100 is the bus that Cromemco so strongly supports with over a dozen plug-in circuits ranging from analog I/O to high-speed RAM memory with our bank-select feature.

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You have to have software. And Cromemco is far in front there, too. Our FORTRAN IV, for example, is equal to the FORTRAN compilers on large mainframes. Further, it (and our other software) is low-priced.

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There's also our Z80 Macro Assembler and Linking Loader. Uses Z80 mnemonics. Allows referencing FORTRAN common blocks.

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Note the separate numeric keypad and cursor keypad.

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SEE AT YOUR DEALER

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See it at your local dealer shown on the other side of this page. He has a demo to show you.

He also has brochures giving you details.

You know the CS-3 is going to be a sensation.

Better contact your dealer now.

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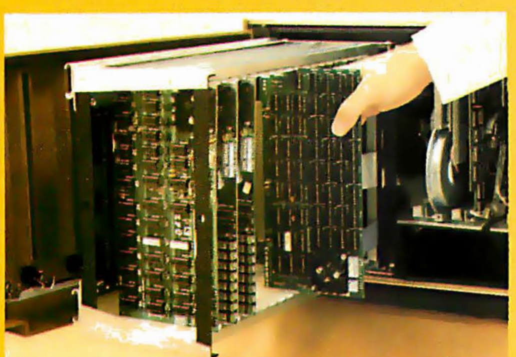
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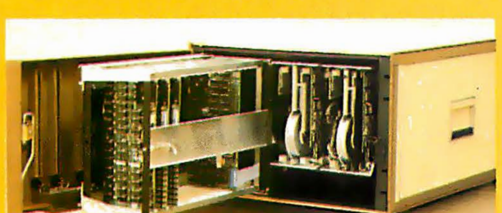
MORE ABOUT THE SYSTEM THREE . . .



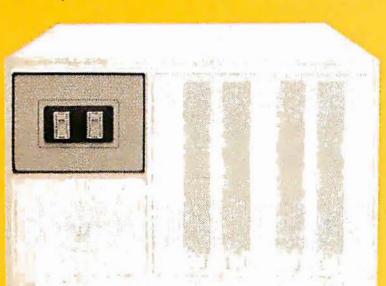
For office situations new System Three can be provided with walnut floor cabinet. Metal bench cabinet also available. Unit is normally rack-mount style.



System Three front panel swings open and 21-slot motherboard/ card cage slides forward for easy insertion of extra circuit boards.



Retainer bar secures circuit cards firmly in sockets.



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BYTE April 1978
Volume 3 Number 4

Foreground

Background

Nucleus

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In This BYTE

About the Cover. . .

This month's cover is the work of Eduardo Kellerman, computed with a simple APL implementation of the "Serendipitous Circles" algorithm with several modifications. The original algorithm was described by authors D John Anderson and William F Galway in an article on page 70 of the August 1977 BYTE. Eduardo's comments upon the modifications to the algorithm form the text of his article Serendipitous Circles Explored, which includes reproduction of 13 original examples he has made. Four of these examples were used as a group to form the cover of this issue.

An important point to mention is that many of the intricacies of this form of display can be realized by any personal computer owner who also has point plotting graphics capability; and for those who have color graphics, further variations worthy of experimentation include assigning color values to each point. *page 178*

The evolution of the TDL system monitor board and its documentation are the subjects of Bradford E Rehm's article, The TDL System Monitor Board: A Writer's View. Also included is a complete description of the various features and applications of the system monitor board. *page 10*

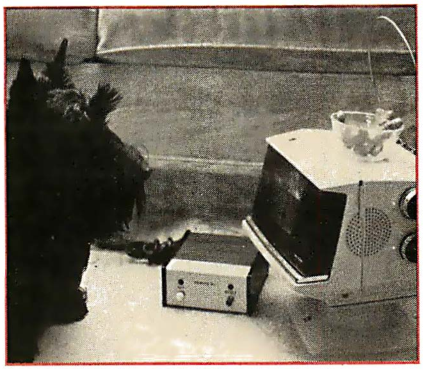
Tables can help you to create more efficient programs. In An Introduction to Tables, F James Butterfield describes different types of tables and helps you to decide which kind is best for your specific need. *page 18*

Number crunching is a subset of the capabilities of the personal computing system. Most microprocessors have limited capabilities built in, capabilities which make programmed higher level arithmetic relatively slow. One way to get around the limitations of programmed arithmetic software for long operations such as multiplication is to implement some specialized hardware. Jack Bryant and Manot Swasdee show How to Multiply in a Wet Climate by adding a MIL spec high speed multiplier to a 6800 processor. This provides a high speed hardware basis for doing floating point arithmetic quickly. *page 28*

What is the ultimate 8080 (6800, 6502, PDP-8, . . .?) multiplication routine? While not promising an answer, William B Noyce provides a direction in which to look for such with his article Optimization: A Case Study. He takes a routine by Christopher Glaeser which appeared in July 1977 BYTE, and proceeds to explore the ways in which the multiplication algorithm can be optimized with respect to execution time, given the limitations of the 8080 instruction set. *page 40*

What's inside the Radio Shack TRS-80 computer? Since the warranty is voided if the case seal is broken, Dan Fylstra cannot take you inside, but he can and does give a functional description of what you get with the TRS-80 in his article The Radio Shack TRS-80: An Owner's Report. *page 49*

With a final installment entitled The Machinery of Emotion and Choice, Ernest W Kent concludes his 4 part series on The Brains of Men and Machines, essential background information for all who would design and implement robotic systems. *page 66*



page 114

One of the computer experimenter's dreams has always been to control lights and appliances around the home by computer, but the thought of installing all the necessary wiring has dampened many spirits. Steve Ciarcia shows you how to get around the problem with a reasonably priced *wireless* AC control system that lets your computer talk to your house. Read Tune In and Turn On, Part 1: A Computerized Wireless AC Control System. *page 114*

Colleges are at last recognizing microcomputers as very useful and versatile laboratory tools. At Algonquin College, Bill Foster and Bob Southern have set up A College Microcomputer Facility. As an introduction to the setup of such a lab, this article may help answer some basic questions other college departments might have about the practicality of a microcomputer laboratory. *page 90*

What's it like to use the Processor Technology SOL terminal computer as a personal system purchased fully assembled and tested? Dennis Barbour, an owner of a SOL-20, reports on his experiences with SOL in his User's Report: The SOL-20. *page 126*

Experimentation with problems of robotic mechanisms does not necessarily have to begin with the mechanisms themselves. Much of the problem of building a robot and making it work lies in the determination of strategies of movement and searching through the environment that the robot inhabits. John Webster's article Robot Simulation on Microcomputers shows how any personal computer with a video display can be used to implement a simple simulation of a robot confined to a playpen. *page 132*

In this month's BYTE, Mike Wilber completes his 3 part series outlining CIE Net: A Design for a Network of Community Information Exchanges with a discussion of "other issues," which help fill in the design. *page 168*

Editorial

Personal Computing:

New Prospects for Art and Science

By Carl Helmers

Changes of State

I'll start by turning attention to the phenomenon of changes of state. In the abstract, the state of a system is the complete set of parameters needed to describe that system unambiguously at some point of time. The dynamically changing universe in which we live is such that changes of state are prevalent in whatever we choose to examine. Life seems fraught with changes of state by its very nature.

In elementary physics, for example, we find the irreversible change of state which occurs when a warm body is placed in a cold chamber without any source of thermal energy, or when an orbiting satellite is placed in a decaying orbit where a slight but measurable atmospheric drag makes a fiery end inevitable. In chemistry, one sees the change of state which is a chemical reaction going to completion after materials are mixed.

On a less directly observable, yet still scientific, basic we find the theories of geophysics and the study of changes of state in the depths of our planet's past. We see residual traces of significant changes of state which must have occurred. We find, for example, a well-defined mechanism explaining the acretion of planets and stars from a proto-stellar nebula. One residual trace of this change of state is the planet Earth and its Moon. A little later in the geological record, we find the change of state which is the evolution of life and its fundamental changes in the chemical composition of the surface and atmosphere of the planet Earth.

The history of the human race on this planet is basically a history of similar changes of state, where the "state" is much more nebulous but nonetheless observable. The state of civilization, as measured by its technologies, has been in a nearly continuous process of change, occasionally marked by landmark discoveries or inventions. Perhaps the first such social change of state was the invention of controlled fire for cooking and heating. Hardly far behind was the invention of the wheel, a basic mechanism of some repute. Somewhere in this sequence came the invention of written language, a major turning point, as was the development of agriculture. In our recent cultural history, there have been a number of similar profound changes of state: printing, controlled mechanical power, controlled use of electricity. Lately we have reached the zenith of the arts of wheeled transportation combined with controlled mechanical power which is the modern automobile. This probably irreversible change has spread like wildfire through the civilized world of the past 75 years or so.

My thesis is that the idea of the personal computer is the latest example of such a change of state in our technological civilization, a change of state which is still far from completion. It represents the harnessing of controlled mental powers, the ability to automate thought processes and procedures freeing the brain for work more creative than rehashing the familiar. In this essay, I'll concentrate upon the implications of the personal computer for art and science, the two areas of our culture which stand to gain greatly from this new technology. We are at a point in time when the technology of computing is within the range of every citizen who *wants to use it.*

Art, Science and Intellect

Art and science are both activities of the intellect. I make this statement knowing full well that "intuitive" artists and scientists may protest this identification, but I believe it is obvious. By intellect, I mean the full range of mental activities, including those not fully understood such as creativity and judgement. I'll offer two definitions which will serve to illustrate the close relationship between art and science, as well as the differences.

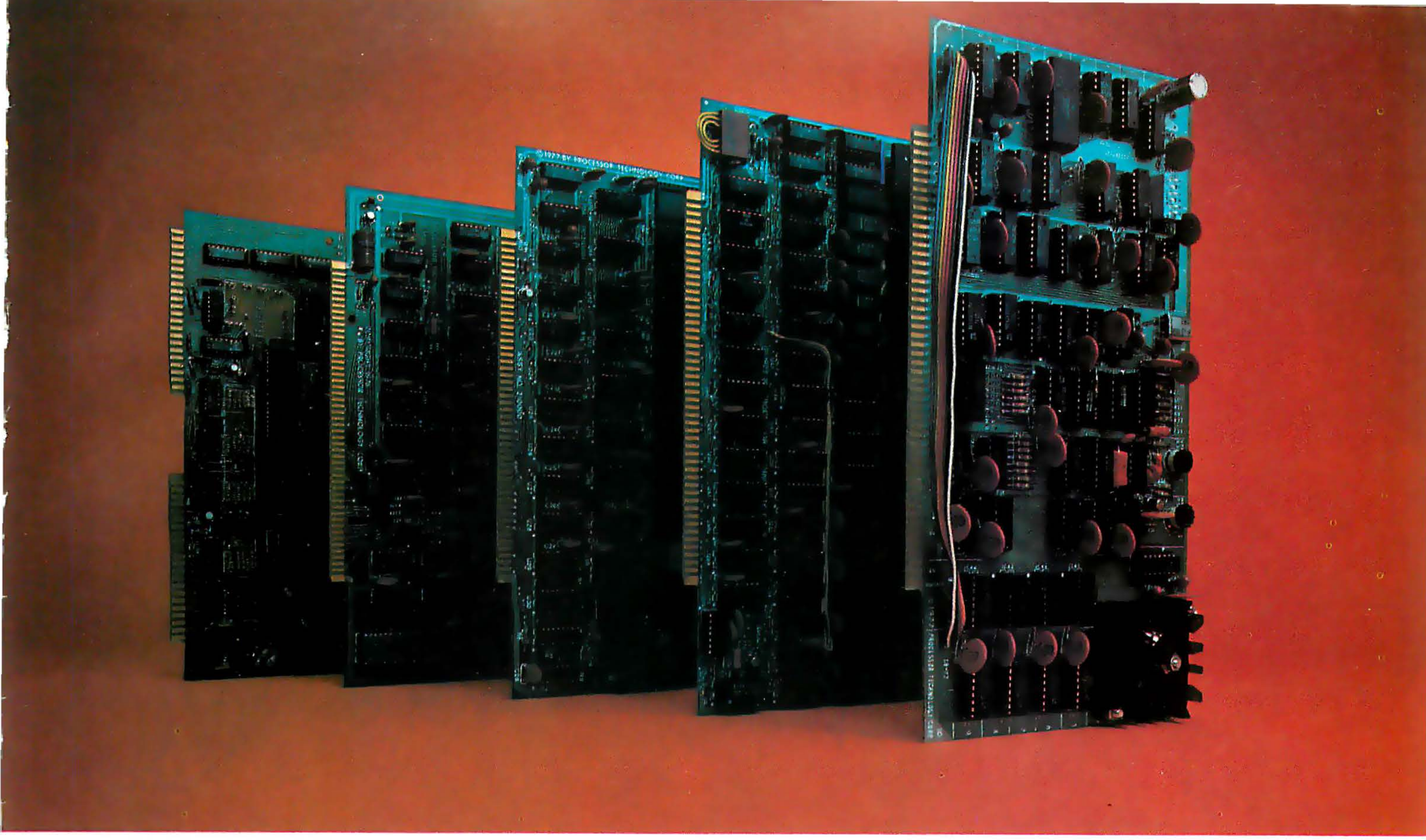
One way to describe a work of art is as a *selective representation* of reality created by the artist to produce an *aesthetic* effect. The nature of the selection process and the identification of the aesthetic purposes

Continued on page 139

Articles Policy

BYTE is continually seeking quality manuscripts written by individuals who are applying personal computer systems, designing such systems, or who have knowledge which will prove useful to our readers. For a more formal description of procedures and requirements, potential authors should send a self-addressed, stamped envelope to BYTE Authors' Guide, 70 Main St, Peterborough NH 03458.

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Each board is a standout. Together, they're a powerhouse.

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Now that our own Sol has become the number one small computer, you might think we're putting less emphasis on our board business.

Not so.

We're just doing more creative things with them.

One neat package gets your computer on the air.

For example, we've built Subsystem B, which ties together five Processor Technology modules into a completely integrated system that makes other S-100 Bus computers work almost as well as our Sol.

Subsystem B includes a memory module, three input/output modules, a general purpose memory, and appropriate software.

A specialized software program called CUTER knits together your computer and its peripherals to create an integrated, smoothly working system.

It's the fastest, cleanest way to get on line, and it costs less than if you bought each module separately.

You get your choice of two low power, reliable memory modules in 8K or 16K capacity.

Our VDM-1 video display module (still $199 in kit) is the industry standard display device with over 6,000 in use.

Our CUTS high speed, low cost ($149 in kit) audio cassette interface is the most reliable on the market and is supported by our broad line of cassette software including Extended BASIC, FORTRAN,* PILOT,* FOCAL and numerous others.

And our 3P+S input/output module offers a low cost way to handle virtually all the I/O needs of any S-100 Bus compatible computer system. There are close to 10,000 in the field. Price is just $149 in kit.

Yes, we may have become the maker of the Number 1 small computer—the Sol. But we haven't neglected the quality of our board business. We can't afford to...because we use many of them in our own computers.

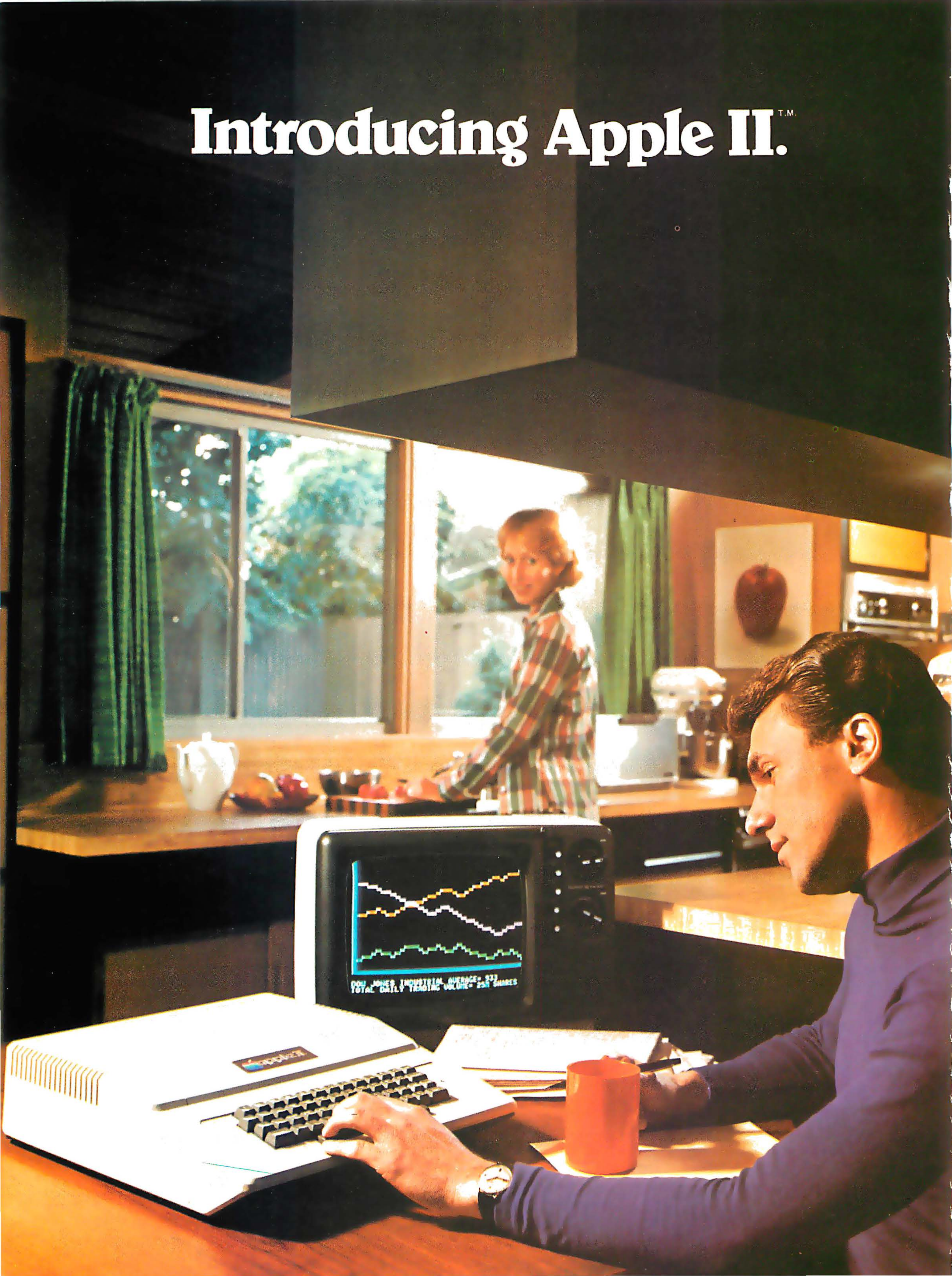
For our most recent literature and price list see your dealer or write Processor Technology Corporation, Box B, 7100 Johnson Industrial Drive, Pleasanton, CA 94566. (415) 829-2600.

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Introducing Apple II.T.M.

The home computer that's ready to work, play and grow with you.

Clear the kitchen table. Bring in the color T.V. Plug in your new Apple II,* and connect any standard cassette recorder/player. Now you're ready for an evening of discovery in the new world of personal computers.

Only Apple II makes it that easy. It's a complete, ready to use computer—not a kit. At $1298, it includes features you won't find on other personal computers costing twice as much.



Features such as video graphics in 15 colors. And a built-in memory capacity of 8K bytes ROM and 4K bytes RAM—with room for lots more. But you don't even need to know a RAM from a ROM to use and enjoy Apple II. It's the first personal computer with a fast version of BASIC—the English-like programming language—permanently built in. That means you can begin running your Apple II the first evening, entering your own instructions and watching them work, even if you've had no previous computer experience.

The familiar typewriter-style keyboard makes communication easy. And your programs and data can be stored on (and retrieved from) audio cassettes, using the built-in cassette interface, so you can swap with other Apple II users. This and other peripherals—optional equipment on most personal computers, at hundreds of dollars extra cost—are *built into* Apple II. And it's designed to keep up with changing technology, to expand easily whenever you need it to.

As an educational tool, Apple II is a sound investment. You can program it to tutor your children in most any subject, such as spelling, history or math. But the biggest benefit—no matter *how* you use Apple II—is that you and your family increase your familiarity with the computer itself. The more you experiment with it, the more you discover about its potential.



Start by playing PONG. Then invent your own games using the input keyboard, game paddles and built-in speaker. As you experiment you'll acquire new programming skills which will open up new ways to use your Apple II. You'll learn to "paint" dazzling color displays using the unique color graphics commands in Apple BASIC, and write programs to create beautiful kaleidoscopic designs.

As you master Apple BASIC, you'll be able to organize, index and store data on household finances, income tax, recipes, and record collections. You can learn to chart your biorhythms, balance your checking account, even control your home environment. Apple II will go as far as your imagination can take it.

Best of all, Apple II is designed to grow with you. As your skill and experience with computing increase, you may want to add new Apple peripherals. For example, a refined, more sophisticated BASIC language is being developed for advanced scientific and mathematical applications. And in addition to the built-in audio, video and game interfaces, there's room for eight plug-in options such as a prototyping board for experimenting with interfaces to other equipment; a serial board for connecting teletype, printer and other terminals; a parallel interface for communicating with a printer or another computer; an EPROM board for storing programs permanently; and a modem board communications interface, or a floppy disk interface with software and complete operating system. And there are many more options to come, because Apple II was designed from the beginning to accommodate increased power and capability as your requirements change.



If you'd like to see for yourself how easy it is to use and enjoy Apple II, visit your local dealer for a demonstration and a copy of our detailed brochure. Or write Apple Computer Inc., 20863 Stevens Creek Blvd., Cupertino, California 95014.

Apple II™ is a completely self-contained computer system with BASIC in ROM, color graphics, ASCII keyboard, lightweight, efficient switching power supply and molded case. It is supplied with BASIC in ROM, up to 48K bytes of RAM, and with cassette tape, video and game I/O interfaces built-in. Also included are two game paddles and a demonstration cassette.

SPECIFICATIONS

- **Microprocessor:** 6502 (1 MHz).
- **Video Display:** Memory mapped, 5 modes—all Software-selectable:
  - Text—40 characters/line, 24 lines upper case.
  - Color graphics—40h x 48v, 15 colors
  - High-resolution graphics—280h x 192v; black, white, violet, green (16K RAM minimum required)
  - Both graphics modes can be selected to include 4 lines of text at the bottom of the display area.
  - Completely transparent memory access. All color generation done digitally.
- **Memory:** up to 48K bytes on-board RAM (4K supplied)
  - Uses either 4K or new 16K dynamic memory chips
  - Up to 12K ROM (8K supplied)
- **Software**
  - Fast extended Integer BASIC in ROM with color graphics commands
  - Extensive monitor in ROM
- **I/O**
  - 1500 bps cassette interface
  - 8-slot motherboard
  - Apple game I/O connector
  - ASCII keyboard port
  - Speaker
  - Composite video output



Apple II is also available in board-only form for the do-it-yourself hobbyist. Has all of the features of the Apple II system, but does not include case, keyboard, power supply or game paddles. $798.

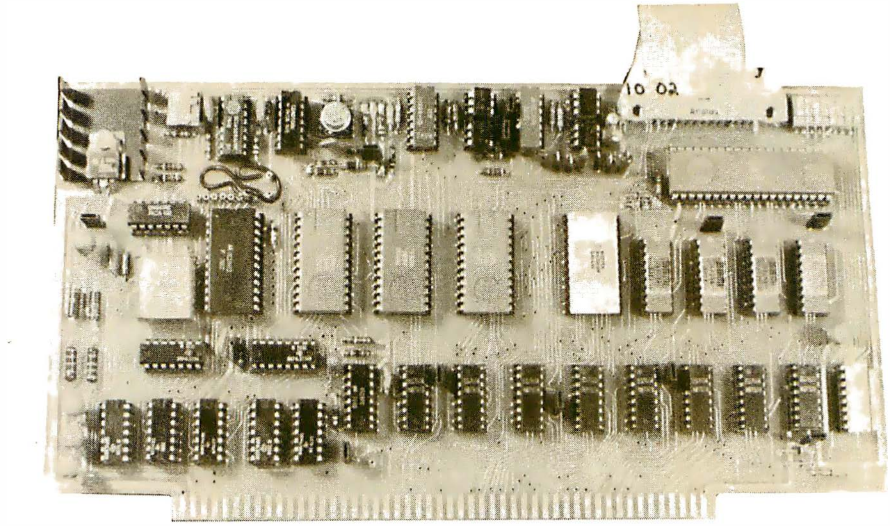
PONG is a trademark of Atari Inc.

*Apple II plugs into any standard TV using an inexpensive modulator (not supplied).

SEE OUR FULL PAGE DEALER AD ON PAGE 105.

apple computer inc.™

Circle 4 on inquiry card.



The TDL System Monitor Board

A Writer's View

Bradford E Rehm
1004 Middle Cove Dr
Plano TX 75023

At nearly the witching hour of a wintry December evening, several of us, including some of the engineering and management staff from TDL, settled down for "lunch" at the Edison Diner in NJ. It was indeed lunch time for the TDL people, who had taken to working night owl shifts so that they could do engineering and software work without being distracted by telephone calls and visiting salespeople. In the course of a conversion which meandered from computers, to memories of our spent youths in New Jersey suburbia, to ham radio and back to computers, I learned that prototype printed circuit boards for a new product were being ordered, but that the staff was having trouble finding time to write the documentation for it. In response to this familiar story, I volunteered to write the documentation.

When I offered to do the work I planned to stop by at TDL, pick up a prototype, and talk with both Mike Simmonds, the design engineer, and Roger Amidon, who is largely responsible for TDL's Zapple monitor. I would also get schematics, blueprints and whatever else had fallen out of the creative maelstrom that gave birth to the new product, the System Monitor Board (SMB). These I would remove to my Rhode Island shore cottage, and after several days I would emerge with the finished user's manual.

What actually happened was that on an ominously cold afternoon several weeks later, Mike Simmonds and I decided that he would fly up from New York, bringing most of the hardware and a lot of the remaining information I would need. Within minutes of our conversation, though, we began to receive the heaviest snowfall of the year. We decided there would be no trips that weekend and that Mike would send a cassette of dictated information.

Now enter a second difficulty: the prototype boards never arrived. And worse, the masked read only memories that held the Zapple monitor were late. It didn't matter that their delivery had been promised and even guaranteed a few days before. They didn't arrive last week, or the week after, or the week after that. It did matter, however, that full page ads were beginning to appear in the magazines, heralding the arrival of the SMB.

TDL patiently explained to customers and dealers that "the product will be available soon; there has been a production delay. We expect to be shipping soon, and. . .we'll do our best. . . ."

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About the Author:

Bradford E Rehm is currently employed as a systems analyst at Texas Instruments in Dallas working with a distributed computer system that uses 960 series minicomputers.

In the end, of course, the SMB made it to the marketplace. I had an interesting if somewhat frustrating experience in long-distance communication, but the board survived its ordeal of creation. Now let's have a look at what survived.

At a time when single chip computers boasting a processor, clock, volatile and read only memory, and IO ports on one die are being announced, a multifunction board may seem less than innovative. The single chip computers are, of course, intended to be used in limited, dedicated applications. The SMB is designed to be the basis for much larger and more versatile systems. It includes the following hardware and software:

- 2 K bytes of masked read only memory containing the TDL Zapple monitor with 26 commands.
- A parallel port terminating in eight switches used to select default IO device assignments for the monitor.
- 2 K bytes of static programmable memory which can be used for program instructions or monitor extensions.
- Two serial IO ports (RS-232C or 20 mA current loop).
- One bidirectional parallel port with status bits.
- A cassette port which is controllable through the Zapple monitor.
- A reset circuit which returns the system to Zapple either at power on or at manual reset.

Logical Device	Default Code	Physical Device
Console:	00	Teletype
	01	video
	10	batch (reader=KBD)
	11	(user defined)
Reader:	00	Teletype (reader)
	01	tape (user defined)
	10	cassette
	11	(user defined)
Punch:	00	Teletype (punch)
	01	tape (user defined)
	10	cassette
	11	(user defined)
List device:	00	Teletype
	01	video
	10	(user defined)
	11	(user defined)

Table 1: Physical devices serviced by the TDL Zapple monitor. The Zapple monitor handles IO in terms of four logical devices: the system console, reader, punch and list devices. These are categorical terms, however, and a punch device, for instance, may in fact be the record function of a cassette recorder.

The SMB board can be used as the basis for a small familiarization system by soldering two Altair (S-100) bus connectors back to back, plugging the SMB into one and a Z-80 processor board such as TDL's "ZPU" into the other. The boards can later be unplugged and inserted in the bus of a larger system. With the addition of the Z-80 processor, the SMB is capable of addressing a variety of peripherals.

Now, let's look more closely at the functions of the board. First, there is the Zapple monitor. This is a descendant of a 2 K byte 8080 monitor originally released by Intel, and whose command structure probably predates the 8080 processor for which it was written. Because of this, Zapple has a number of commands familiar to many microcomputer users:

D	=	Display memory in hexadecimal.
F	=	Fill memory between two locations with a hexadecimal value.
G	=	Go to a location in memory and execute the program found there. Two breakpoints can also be set.
H	=	Display the sum and difference of two hexadecimal numbers.
J	=	Test memory between two locations. Indicate locations of defective bits.
M	=	Move a program to another location.
P, T	=	Put or type ASCII characters in memory.
QI, QO	=	Input from, output to a port.
S	=	Examine and, if necessary, substitute a byte of data in memory.
V	=	Verify that programs in different regions of memory are identical, or display differences and their locations.
Y	=	Search for and display the locations of a byte or bytes of data in memory.

Other features of Zapple include variable IO device commands and device service routine vectors. Zapple handles IO in terms of four logical devices: the system console, the reader, the punch, and the list device. One member of a group of four physical devices may be assigned for each logical device; the assignments may be made by default or dynamically. The two serial ports, the parallel port and the cassette port on the SMB, handle five of the physical devices

(the punch is assumed to be connected to the Teletype). Six more devices are handled by user written routines accessed through vectors located between hexadecimal F800 and F823. Table 1 shows the relationships between the logical and physical device options.

The assignments of default IO devices to each of the four logical devices are done with a set of eight switches, grouped as pairs. The binary default code for each device is determined by the settings of each pair of switches. Thus for the console device to be defaulted to a 300 bps video terminal, the binary code 01 would be set in the pair of switches assigned to the system console device. (The switches for all the defaults are found in one dual in line (DIP) 8 pole pencil switch located on the board.)

In addition to setting the sense switches, one must jumper the video serial port for 300 bps, a simple matter of placing an Augat pin in a clearly labelled socket. The cassette port on the SMB will be selected whenever any of the READ, WRITE (in Intel hexadecimal format), LOAD and UNLOAD (in binary format) commands are used. Finally, when a list command (eg: in the TDL text editor) is used to print a buffer of information, the list device will be called.

If the latter requires serial data, the serial IO port on the SMB ("video") could be used here. The list switches would be set at 00. If the printer is a parallel input device, the parallel port on the SMB could be used. The data would be applied to lines PD0 thru PB7 on J1, the multipin connector (visible in photo 1) which is the IO connector for the SMB. The status line from the printer would go to CB1 on J1.

But since we may want to save the parallel port for other purposes, which will be discussed later, we can route the list output through a user vector to an external (to Zapple) device service routine and port. The user defined list option sends the processor to hexadecimal address F815 in the vector area of programmable memory, just above Zapple in memory address space. A JMP (C3) instruction must be inserted here to tell the processor where to go next to send characters to the printer. The device service routine must end with a RET (C9) instruction to get back into Zapple.

The first thing one should be aware of in using the parallel port on the SMB is that it is bidirectional. Many processor chips provide data buses which are bidirectional: they can output data to and receive data from the bus on the same eight lines. The 8080 and Z-80 processors do this. But, curiously, the now widely used Altair (S-100) bus is not bidirectional and uses separate sets of eight lines for sending and receiving data to and from the processor.

There is something to be said for splitting the in and out functions of the bus. If, for example, the input lines are used to receive data from an analog to digital converter being used for games, the output lines would still be available for controlling up to 255 other devices, such as tape recorders, air conditioners, lights, disks and coffee pots. But microprocessors do only one thing at a time (input or output) anyway, so no real advantage is obtained at a price of extra and more expensive hardware.

On the other hand, a bidirectional port is useful for high-speed transmission of data between the main processor and peripheral devices. A floppy disk which, for example, lacks an interface for a particular bus will, chances are, be accessible through one or two bidirectional parallel ports. Lab instruments, additional memory and slave processors are also normally designed around bidirectional parallel interfaces. So it appears that having such a port on the SMB opens up some interesting possibilities.

The feature to which most readers will look with a mixture of interest and skepticism is the cassette port. The interface is well-serviced by the Zapple monitor. Any of the functions available to the paper tape reader and punch are available to the cassette port. To save a program written in the text editor, for example, simply type a U, and the entire text buffer will be dumped. To reload the text, a 50 line block can be retrieved with an A command. The As can, of course, be concatenated: typing three of them brings in 150 lines for editing.

User written programs can be saved in binary or Intel hexadecimal format, and programs written by the TDL relocating macroassembler (including all TDL supplied software) can be relocated using the Zapple commands and the cassette interface. I find this a convenient system to use and can report only one shortcoming which might reasonably have been included (if there were more room available in the 2 K byte monitor). It does not recognize files. One cannot, for example, type R(EAD) LIFE, start the cassette, and wait for the system to find and load the file named LIFE.

The reason we will probably never see

a file-oriented cassette system from TDL is that the company is currently committed to designing a disk software package.

How difficult is it to make the cassette interface work? Storing data on cassettes can be difficult with some interfaces and some recorders, because it involves interfacing digital systems with analog systems. The simplest problem to deal with involves played back material in the wrong phase for proper decoding. Changing a jumper or a switch setting on the board usually cures this.

The level of the signal to be recorded may be too high or too low for the input circuitry of the recorder to record it properly. The output voltage of the recorder may not be sufficient to properly drive the interface receiver (input) circuitry. The SMB interface provides switch selected record levels and a sensitive receiver interface.

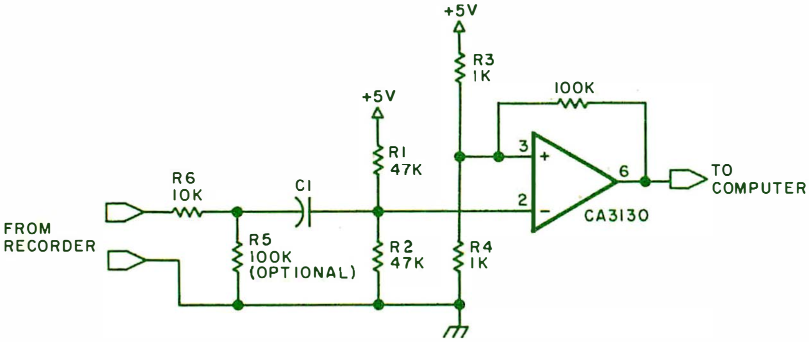


Figure 1a: The original design of the TDL system monitor board cassette receiver interface circuit. Both op amp inputs are biased with separate resistor networks.

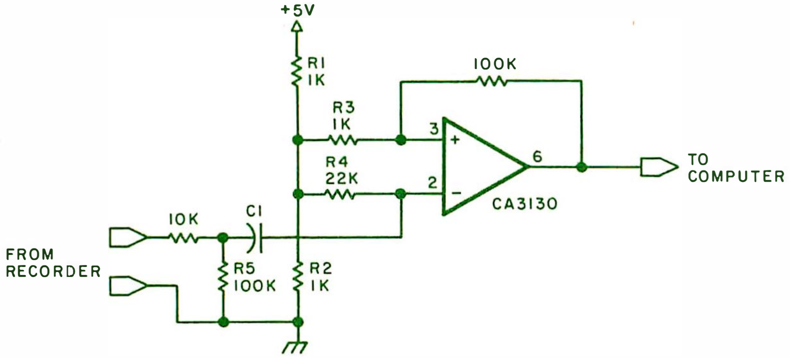


Figure 1b: The new version of the cassette receiver interface circuit featuring a single resistor network that drives both op amp inputs and provides stabilized sensitivity. R3 provides isolation between the two inputs. In both these circuits, software decoding of tape data is assumed; generation of data is much simpler and is done with software also.

The output levels available will satisfy the requirements of most recorders' microphone inputs. The RCA CA3130 op amp in the front end of the receiver is the solution to problems I have encountered in driving some other interfaces. My recorder, which uses a single integrated circuit for all its record and playback functions (and which consequently lacks the output power of some of the larger machines), can drive the SMB with volume control set near the bottom of its range. This adjustment is not critical by the way. A nearly full scale setting seems to work as well as a low one.

There was some initial difficulty in making the interface work, but those who buy current versions of the SMB should have no trouble. The original design, shown in figure 1a, biased each of the op amp's differential inputs with separate resistor networks. If the idle state offset between the inputs is near 0, the output of the recorder will easily drive its input to an offset condition, causing an output deviation to appear at pin 6. If a component in one of the bias networks should change value, however, the permanent offset error this would introduce could swamp the input signal.

My SMB, a prototype, worked perfectly for a few weeks after it was set up. Then it lost sensitivity to the extent that I could barely drive it with a 20 W amplifier. A call to TDL produced the modified circuit shown in figure 1b. The bias points for both op amp inputs were now set by a single divider network comprised of R1 and R2. The new R3 (1 K) provides isolation between the two inputs, and the new R4 (22 K) is set at approximately the parallel value of the old R1 and R2 (see figure 1a). In this way, the time constant of the high pass filter formed by C1 and R5 is maintained.

The sensitivity of the modified circuit is somewhat better than it had been originally. When good quality cassettes are used and normal tape handling precautions taken, tape errors are extremely rare. 8 K bytes of data can be loaded in about 190 seconds. This seems a long time, considering that the interface is supposed to operate at 1200 bps. Another unit I have used can load the same amount of data in less than 60 seconds. The reason is that the SMB is loading in hexadecimal rather than binary format. The former takes about three times as long because it includes the information necessary to make assembled programs relocatable. If it is important to reduce the

loading time to under 1 minute, users can load and locate a program (say BASIC) using the hexadecimal loader. Then, saving it in binary format, using the U command, would permit reloading it, using the L command, in about 55 seconds.

There is an interesting trick some users will appreciate if they set up systems with bus driven video displays such as the Processor Technology VDM-1 or TDL's own video board. Zapple allows one to assign the system console to a "batch mode" configuration. This makes the reader logical device the system keyboard and the list device the console output. Consider defining the cassette port as the reader device and using it to input a series of commands which would load extensions of Zapple into memory and then return control of the system to the designated console. It works. And the 2 K bytes of programmable memory beginning at hexadecimal F800 is a convenient place to put the extensions. If the keyboard data is to be input through the parallel port, an external driver routine will also be needed. This means that the system must be initialized in batch mode so that the extensions can be loaded on startup. A program is available from TDL to do this. It assumes the system is started in batch mode, and brings up a keyboard on the parallel port and a VDM-1 display.

I can't claim that the user's manual is a literary masterpiece, but as a means of getting across basic information about a fairly complicated piece of equipment, it will do. The use of the parallel port is not adequately explained; there is no parts layout drawing and there are no detail illustrations. In spite of these shortcomings, I believe a careful beginner could assemble the SMB in two or three evenings without encountering any serious obstacles. I say this because the assembly instructions are clear and make good use of the silk screened parts layout on the board itself.

For those who are interested in getting a microcomputer system up and running with a minimum of fuss and bother, the SMB is one option to consider.■

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An Introduction to Tables

The construction and use of program tables is the gateway to developing powerful programs. The new programmer may have trouble getting to know the concept of tables, but time spent learning about tables is well worth the effort.

The first few programs to go into your home computer are likely to be written using a multitude of IF tests: If a value equals 1, branch to a particular routine; if equal to 2, another branch; if over 5, yet another branch; and so on. After a while this gets to be a lot of work. Programmers quickly learn to use table structures to simplify decision making.

Tables are called by many names, depending on the language and the application: arrays, vectors and matrices, to name three. Even the concept of a "file" is usually just a large table which follows the same structural rules but is stored on disk or tape.

Table Elements

Most of the tables we meet in books, forms and so on consist of data arranged in rows and columns. Each row usually contains a record about something. Name, address, age, phone number might be the record of a schoolmate. Each item of this record, such as name, is called a field. In most cases, each record contains the same number of fields; this is called a rectangular table because of its appearance when printed, and is by far the easiest type to handle.

Rows and columns can be interchanged, of course, by laying the table on its side. Let's look at two ways to encode this small table:

Name	Age	Phone
Joe	14	515-3838
John	18	216-3001
Pete	17	414-3377

First we could encode each line this way:

record 1	field 1	Joe
	field 2	14
	field 3	5153838

This is the most common, and usually the handiest way to set up the table. It's logical, easy to change or to add new items, and not difficult to program a search routine for. All the data for a particular line of the original table is in one record. However, during this search, we must leap 12 bytes or so each time we wish to examine a new record. This may or may not be convenient to do, depending on hardware characteristics. By laying the table on its side, we could write:

record 1	field 1	Joe
	field 2	John
	field 3	Pete
record 2	field 1	14
	field 2	18
	. . . etc	

This method is in some ways like devoting a separate table to each kind of data in the big table: a table of names, a table of ages, etc. This type of organization might make it a little easier to search for a name, but it becomes tougher to add a new name to the list, and harder to read. But either way works.

Order of Items

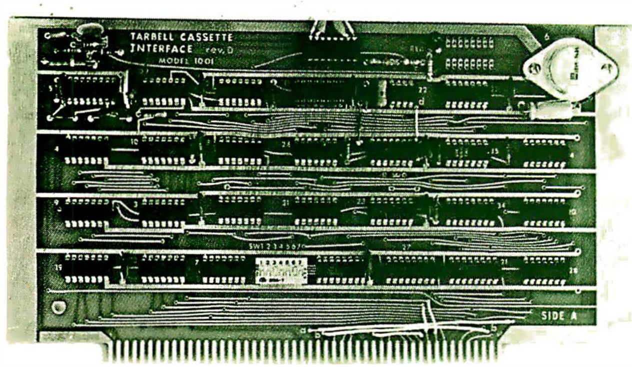
One of the most important decisions you must make in designing a table is how to order the records. For small tables it doesn't matter very much. But as tables get bigger, it becomes important not to waste time on lengthy searches.

At first glance, the simple answer is to put the most often used items at the top of the table where they'll be found first, a procedure which frequently works well. But you must know roughly how often each table item is likely to be used. If the usage pattern changes, your table lookup becomes inefficient. Beware of elaborate schemes to

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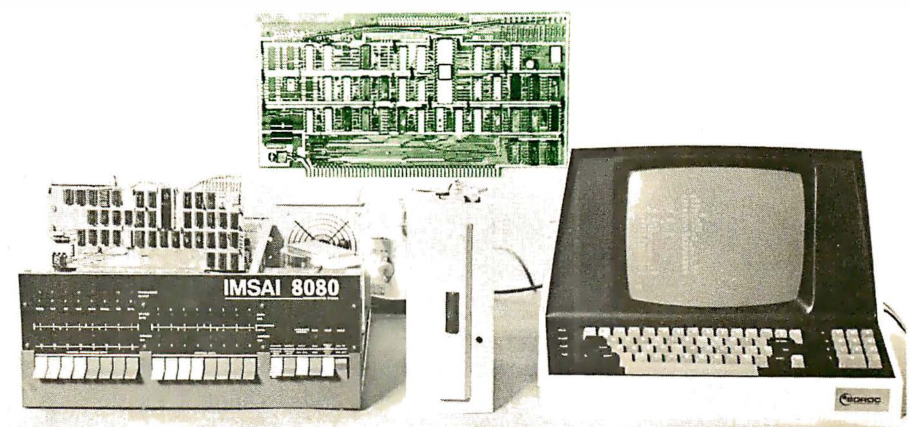


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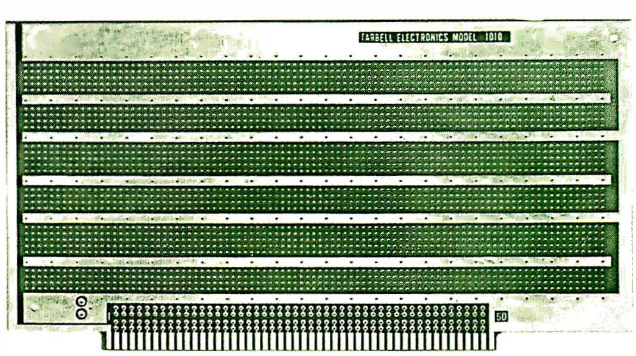


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rearrange the table order as usage changes: they can quickly use up more time than they save.

An excellent method for ordering tables is to use the table address itself as the item to be matched. Let's clarify this with an example. Suppose we have a character in Baudot (5 level) code that we want to translate, say, to ASCII. The lowest value possible is blank, or 00000 (decimal zero). The highest value is the letters shift, or binary 11111 (decimal 31). If we add this character, as a binary number, to the table base address, we'll create an address ranging from TABLE+0 to TABLE+31. In each of these table locations, the corresponding ASCII character will be stored. We'd have to make provision for both upper case and lower case Baudot, of course. The important thing about this kind of table is that we never have to search it. We go straight to the address we want.

The most common way of ordering items in a table is sequential, ie: in ascending or descending order, alphabetically or numerically. Usually we must pick one particular field for the sequence, the one we expect to search most often.

We get many advantages when we have a sequential table. The program can detect right away if it has "gone past" the item it's looking for, so that it won't waste time searching through the rest of the records. With a little more programming effort, we can write a binary search program that passes through a table very quickly. The binary search routine works by examining the middle of the table and deciding if the desired item is above or below this point. From then on, the program concentrates exclusively on the remaining half of the table, and looks at its midpoint in the same way. Each step cuts the remaining portion of the table in half; eventually the desired location is found or a conclusion of "no match" results.

A sequential table is the only type that can be used for a continuous value calculation. You may recognize the following partial table:

Income	Tax
less than 2350	0
less than 2375	2
less than 2400	5
.	
.	
.	

This table associates a continuous value, income, with unique tax amounts. If your income was $2378.54 you do not escape tax because there isn't an exact value of $2378.54 in the table. For your program to find such an intermediate value, the table must be sequential.

There are several drawbacks to sequential tables. The first is the problem of getting the table in sequential order and keeping it that way during deletions and additions. The second is that only one field is in sequence. This means that the user may have to re-sort the whole table to start searching on a new field.

Advanced Techniques

When it is desired to arrange a table in some order, there may be some difficulty moving the items around, especially if they are large and clumsy.

One way to get around this is to leave the data in its original order and build a separate table called an index which gives the order in which the data should be read. This way, instead of moving the data around, the index is simply changed as necessary.

Another way to achieve a similar effect is by chaining. This attaches an extra field to each record which points to the record to be looked at next. The program must have a starting point that tells which record is to be examined first. From then on, the program follows the chain to the last record.

Indexing and chaining are both relatively complex, but they have one important advantage: the same file can have two indices or two chains so that it is simultaneously sorted two different ways. This feature can sometimes eliminate many time-consuming sorts.

Tables which are not rectangular are a source of difficulty. If we are recording, for example, names of parents and their children, we soon face the problem of some parents having only one child, while others have seven or more. Should we allow seven slots for each set of parents and waste precious memory? We could build a complex table structure to allow for a variable number of fields (children). This is practical, of course, but sometimes we can eliminate the problem by making the table into a list of the children rather than the parents.

Another special case which is often encountered is the triangular table, which resembles a square split along the diagonal, with the two halves containing the same numbers. For example, if you calculate a table of mileages between cities, you don't need to store both the Buffalo to Denver and the Denver to Buffalo mileages; they are of course the same. But trying to store only half the table to save memory turns out to be a difficult task. You'll need a medium sized program to get to the right spot in the table.

Access

The addressing modes of your machine warrant study to determine the best way to scan tables. If you have a hardware index register, that's usually the best way both in terms of speed and programming convenience. Each microprocessor has its idiosyncrasies. An 8 bit index will only cover a table size of 256 locations. Sometimes, though, an index doesn't modify a full address, but only an 8 bit offset. In this case the index must hold a full address rather than a simple table position. How easy is the index to modify as you step through the table? An increment command that adds one to the index value is of limited value if you want to jump 12 locations at a time.

If indexing isn't convenient for a given job, indirect addressing is the next best bet. Put the address of the start of your table into an indirect address location; then add to it as necessary until you reach the end of the table.

Don't hestitate to search a table backwards if it's convenient. This facilitates searches when using certain types of indexing.

Program Intercommunication

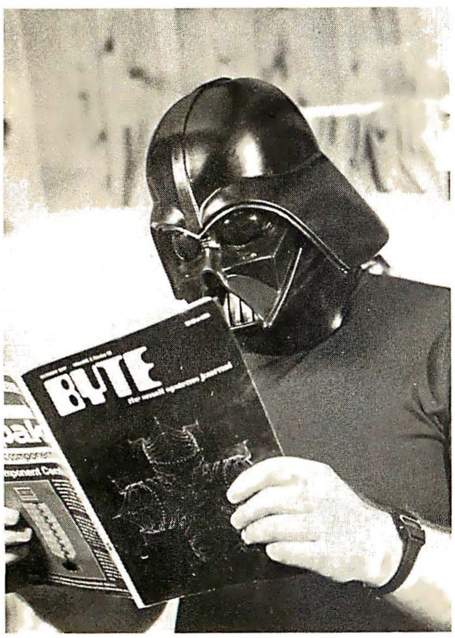
One program segment can communicate with another by means of tables. In fact, processors which feature a common memory use this technique. When working with an interrupt structure, the recommended procedure is to have one program prepare a table of material for another to pick up. This becomes a good way to segment large projects into convenient modules. Each module can be separately debugged by preparing a set of test input tables and examining the output tables it produces. On very large jobs, this kind of segmentation is an excellent way to divide work among several people. Even on line debugging becomes easier, since the tables can be readily viewed at any time.

Conclusion

Tables are a good way to arrange data in a compact, visible and easy to modify form. New programmers sometimes have problems getting used to designing and using them, but they are well worth the effort.■

Letters

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                        WARMEST REGARDS,
                        MR. D. VADER
                        SAN DIEGO, CA

P. S.  I WILL NOT SOUND ANYWHERE NEAR THIS NICE
       AFTER I GET MY ARMY TOGETHER.

END MESSAGE
```

COMMENTS ON STAR TREK TECHNOLOGY

Concerning the speculative article titled "The Computers of Star Trek" by Schmucker and Tarr in December 1977 BYTE, it appears that they have overlooked several pertinent points.

Firstly, it should be noted that since the *Star Fleet Technical Manual* is derived from an unauthorized transmission it is at least possible that the copy used as a source was not current and/or did not contain or reflect all modifications made during repairs, refittings, or in the field.

Secondly, cryogenic temperatures (as well as weightlessness and hard vacuum) are available for free in space. By enclosing the memory banks in a pressure cylinder which communicated with the exterior of the ship, the Josephson junction memory would be feasible by today's technology. Indeed, this would appear to be the exact method used in HAL's (of *2001: A Space Odyssey*) memory banks, and that was set considerably closer to us in time. Since energy fields are known to work through free space (tractor beams), the memory banks could still be enclosed by their protective fields.

Thirdly, the subject of voice recognition. It is assumed that English is the language of the *Enterprise*. Since, however, all members of the Star Fleet (which is supposed to be multinational), Star Bases, inhabited planets (known and newly discovered), Klingon and Romulan Empires, and most intelligent creatures encountered also speak English, I propose that this is artistic license. This opens the possibility that the language of the *Enterprise* is some more universal, perhaps simpler language, possibly on the nature of Esperanto.

Additionally, the development of "talking" computers would, over a period of time, inevitably have an effect on the language of the programmer. Thus, sentence structure, word choice and arrangement would begin to more closely match the computers' optimum requirements to speed input and to



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facilitate output. This would lead to simpler, more concise speech in general, which would make programming tasks simpler. It would also probably have a negative impact on the society's literary capabilities, but that is not pertinent here.

Gary Wells
2622 NE 14th
Portland OR 97212

SOME QUESTIONS ABOUT THE TECHNOLOGY OF EMOTIONS IN THE ENTERPRISE

I would like to commend you all on the excellent article by Schmucker and Tarr, "The Computers of Star Trek," in December 1977 BYTE. It is always intriguing to speculate on such things.

My favorite episode was missing. I refer of course to the time that the computer, with an obviously feminine voice, fell in love with the captain. Such behavior from a purely logical machine seems a contradiction if we are to believe the authors' views as expressed in the character of Spock.

Spock seems capable of separating his emotions from the decision process better than most of the humans on the crew and thus his decisions are respected by the crew members. Such a situation implies that the authors believe that this separation is good.

Questions:

1. How much memory is required for emotions?
2. How do the emotions of the machine alter the decision process?
3. Do the emotions add to the validity of the decisions?
4. What did the computer expect the captain to do once he knew she was in love with him? Was it illegal? Could it be illegal?

Albert C Brunelli
RFD #1
Berlin NH 03570

Pi AYE'D

"The Computers of Star Trek" (December 1977 BYTE, page 12) interests me both as a computer professional and as a Star Trek fan. Schmucker and Tarr are to be congratulated on combining the entertaining with the informative. (It is unfortunate, however, that the only widely available hard copy version of the Star Trek episodes is the James Blish series. The late Mr Blish was often forced to oversimplify because his publisher insisted that he adapt six or more hour long episodes into each volume. He also had a tendency to simply make things up.)

Continued on page 162



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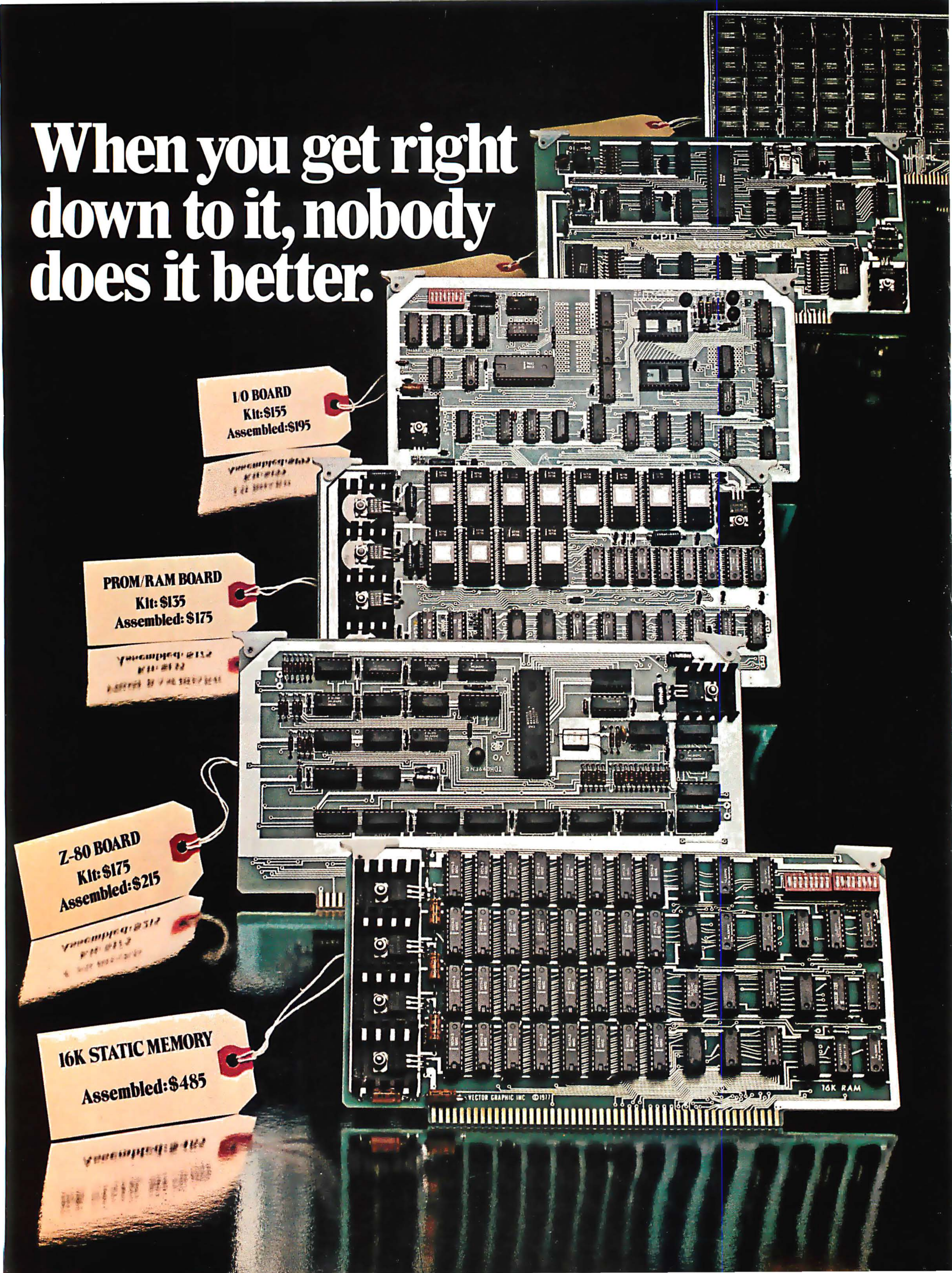
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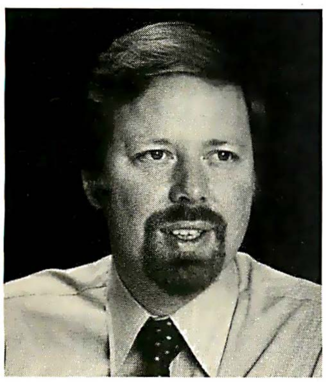
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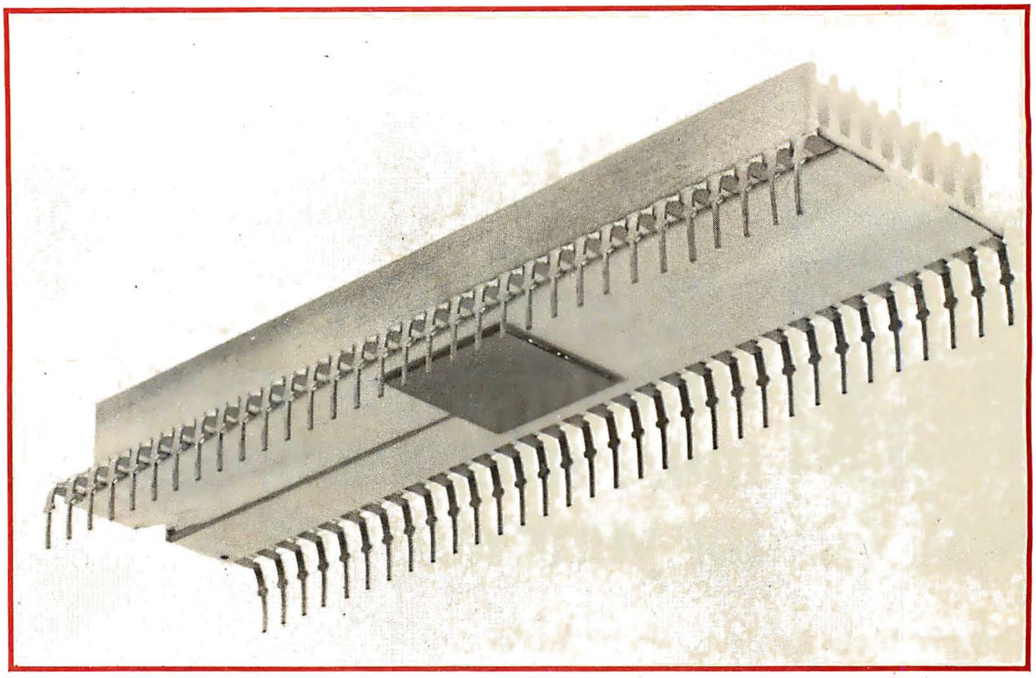


Photo 1: If high speed multiplication is your objective, the MPY-8AJ-M (or its cousins) can provide the large scale integrated circuitry needed. This photo shows the packaging of the 16 bit version of the TRW product with its integral heat sink (it dissipates 5 W and sells for $255 in 100 quantities as part number MPY-16AJ-M). Of more interest to the experimenter, due to lower cost, is the MPY-8AJ-M part which sells for $115 in 100 quantities, and is the subject of this article. TRW is located at One Space Park, Redondo Beach CA 90278.

How to Multiply in a Wet Climate

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Texas A&M University
College Station TX 77843

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Texas A&M University
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An 8 by 8 bit parallel two's complement multiplier, forming sign and a 14 bit product, was recently introduced by TRW Electronic Systems Division. Designated the MPY-8AJ, the multiplier is a low power high performance bipolar TTL device, forming the product in a typical 130 ns multiply time. This time is an order of magnitude shorter than usual microprocessor instruction execution time. Photo 1 shows the beauty contest photograph of this part, as supplied by TRW. Figure 1 is a block diagram of input, output and control for the device. The product is available in a 40 pin DIP ceramic package, 0.600 series. Single power supply of +5 V and under 2 W power consumption add to the attractiveness of the MPY-8AJ as an addition to microcomputer hardware.

We can do two's complement multiplication with software; what we gain using the MPY-8AJ is speed. We think such a device will have wide interest among readers. We decided on the following goals to guide hardware design and software development:

- Multiple precision fixed point arithmetic with faster multiplication.
- Fast double subscripted array access (in a microprocessor with indexed addressing).
- A complete floating point package with fast multiplication.
- Best use of hardware to do things which are slow with software.

We decided to begin with the Southwest Technical Products Corporation 6800 system. The SwTPC product has on mother board decoding for addresses 8000 to 801F (in steps of four bytes). SwTPC documentation refers to an address in this range as a "port," with port 1 (having addresses 8004 to 8007) being dedicated to MIKBUG oper-

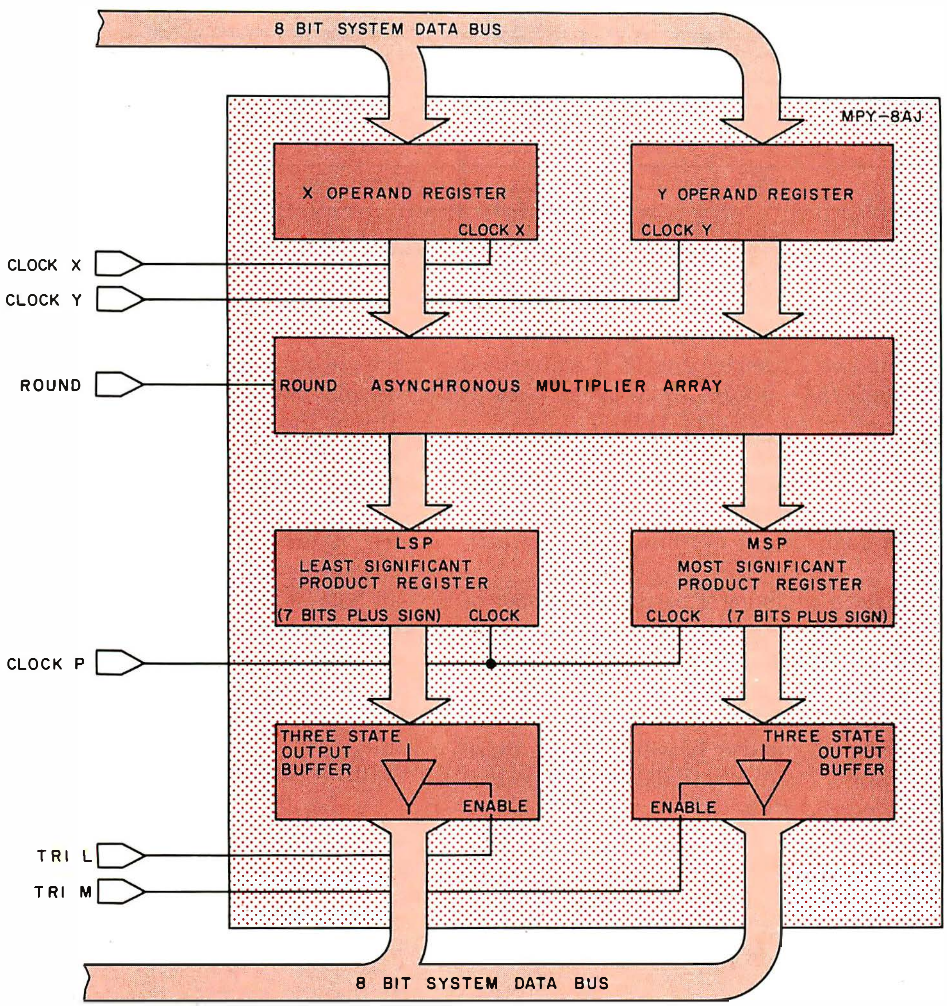


Figure 1: A block diagram of the MPY-8AJ part. The multiplier is fully buffered by registers: CLOCK X writes the contents of the X inputs into the X register, CLOCK Y writes the contents of the Y inputs into the Y register, and CLOCK P writes the outputs of the multiplication array into the product registers. Each half of the product register is in turn provided with a three state buffer with output enable control TRI-L and TRI-M. The ROUND input adds 1 to the least significant bit of the most significant product during a multiplication.

Part 1: Use and Basis for a Design

ating system IO. The advantage to this system is the hardware need only decode 2 bit wide addresses. The user might thus think of the multiplier as an IO unit. The problem is to best return the 14 bit plus sign product, and the answer to this depends on how the product is used. Here we start (from scratch) and discuss number systems and how the MPY-8AJ can support our design goals. Detailed construction information will be presented in the second part of this article.

Number Systems

A typical 8 bit microprocessor instruction repertoire includes instructions that add, subtract and compare numbers in two forms: as unsigned binary numbers and as two's complement signed numbers. The two's complement signed representation allows the hardware to add in exactly the same way for unsigned or signed numbers. The range of 8 bit unsigned binary numbers is 0 to 255, while two's complement numbers (in the same order) range from 0 to 127, −128 to −1.

Were one's complements used for negatives, a negative number would simply give significance to the zeros instead of ones. A two's complement negative number is one greater than the one's complement of the positive number of the same absolute value; this means zeros to the right of the rightmost 1 have no significance in either representation. On the other hand, leading zeros in a positive number and leading ones in a negative number have no significance. For example, 00010010 represents the number 18 and 11110010 the number −14. Later, when we consider numbers of more than

Table 1: Comparison of two's complement and unsigned binary eight bit addition. Although the bits are all the same, the way we interpret an overflow or carry condition distinguishes the two systems.

Example	Two's Complement	Overflow	Unsigned	Carry
a	127+(−1) = 126	Clear	127+255 = 126	Set
b	64 + 64 = −128	Set	64 + 64 = 128	Clear
c	127+(−128) = −1	Clear	127+128 = 255	Clear
d	−128+(−128) = 0	Set	128+128 = 0	Set

8 bit length, we will see (for instance) the 15 bit two's complement 18 is represented by 0000000 00010010 whereas −14 is represented by 1111111 11110010.

In table 1, we give four examples of 8 bit addition as two's complement and unsigned numbers and give the condition of carry and two's complement overflow flags after each sum.

Instead of fixing a particular number of bits, we might as well do them all at once. Take a bit pattern $\beta_0\beta_1 \ldots \beta_n$ of length n + 1 (each β_i is 0 or 1); we can connect an unsigned binary number B_u and a two's complement number B_t with this bit pattern as follows: [*Here we use the convention that the most significant bit is numbered 0 . . . CH*]

$$B_u = \beta_0 2^n + \beta_1 2^{n-1} + \ldots + \beta_n$$

$$B_t = -\beta_0 2^n + \beta_1 2^{n-1} + \ldots + \beta_n$$

The bit pattern $\beta_0\beta_1 \ldots \beta_n$ may also be regarded as a proper fraction (mantissa) B_m between −1 and $1-2^{-n}$:

$$B_m = -\beta_0 + \beta_1/2 + \ldots + \beta_n/2^n$$

This amounts to placing the binary point to the left rather than the right. In this system, two's complement overflow means that the sum is in an improper fraction. For example, the two's complement binary version of decimal 64 is 01000000 in this notation. This is the fraction 1/2, and 1/2 + 1/2 = 1 (example b in table 1) which is not a proper fraction, as indicated by overflow.

The simplest (next to 8 bit) number system is the addressing system: 16 bit (or n bit) unsigned integers specify each address in address space. Sometimes we spend as much time figuring out where things are as we do computing. One goal of using the multiplier was to calculate addresses quickly.

Matrices Anyone?

A *matrix* is a two-dimensional rectangular array of quantities. In BASIC, for instance, the statement

```
10 DIM R(30,20), S(3,2)
```

establishes R to be a 30 row by 20 column matrix and S a 3 row by 2 column matrix. If each floating point number in the matrix were four bytes long, R would occupy 30X20X4 = 2400 bytes (plus bookkeeping) and S would occupy 3X2X4 = 24 bytes (plus). The "plus" is necessary because one must know at least the starting (base) ad-

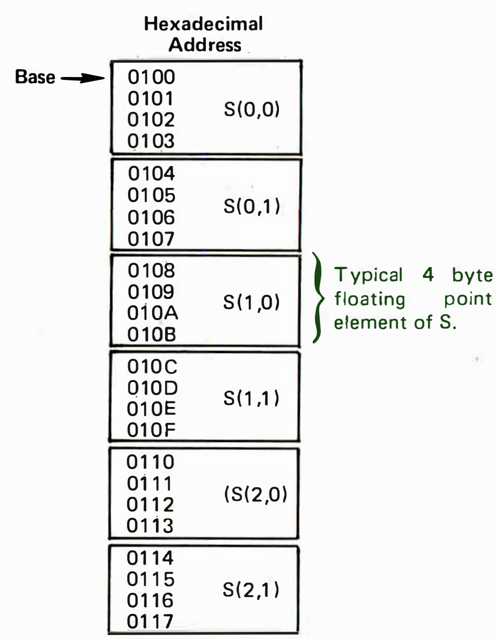
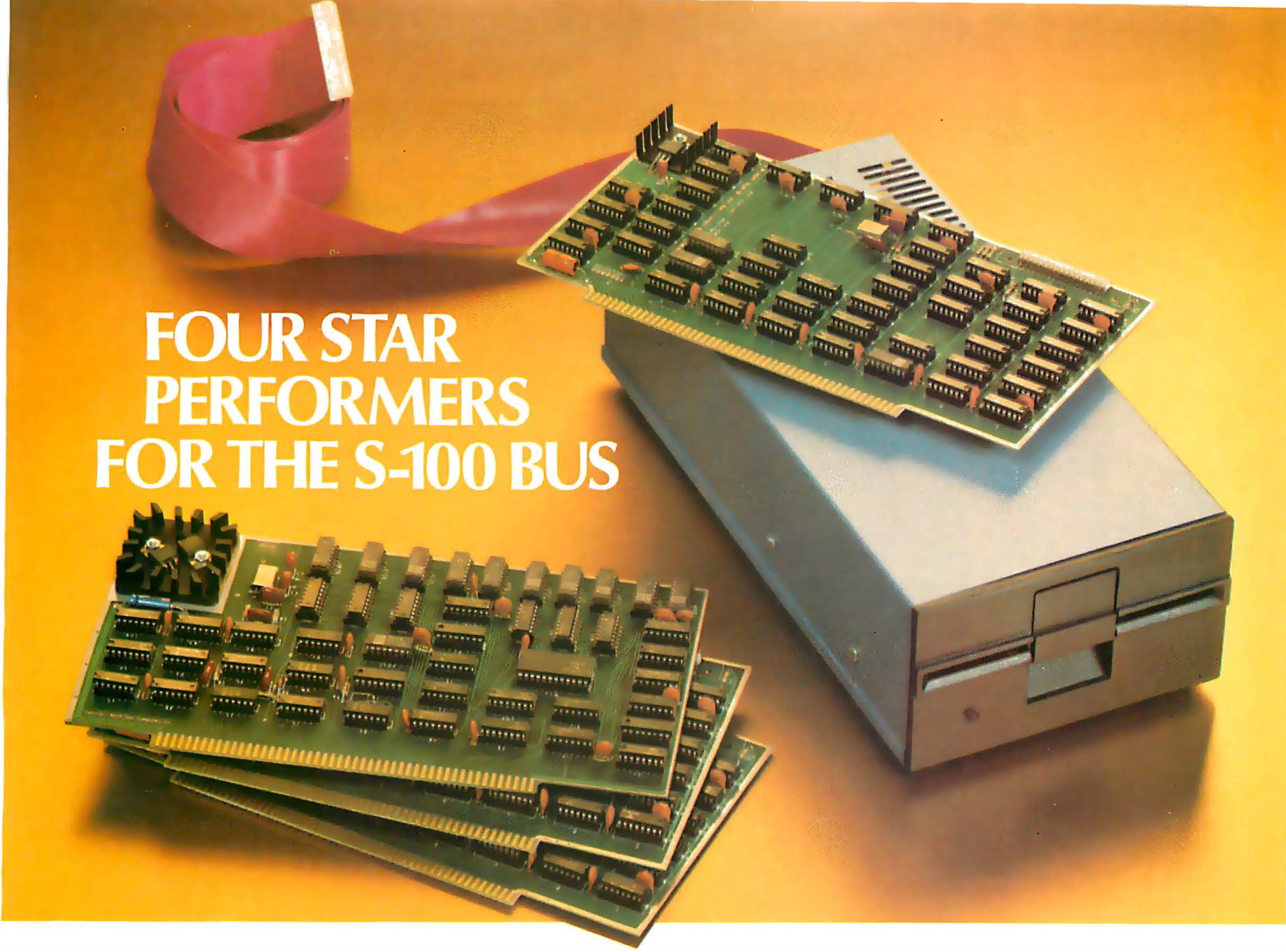


Figure 2: A major use of fast multiplication hardware is in the calculation of address offsets when randomly accessing elements of an array. Here we show a simple memory allocation layout of a 3 by 2 matrix of 4 byte floating point numbers starting at hexadecimal address 0100 in memory address space. The expression:

Element Address = BASE + 4 x (J + 2xI)

finds the address of the (I,J)th element where I runs from 0 to 2, and J runs from 0 to 1. In this example, BASE has the value of hexadecimal 100. This calculation must be done whenever it is desired to reference a particular element of the array and there is no constraint upon the subscripts which could possibly simplify the calculation.



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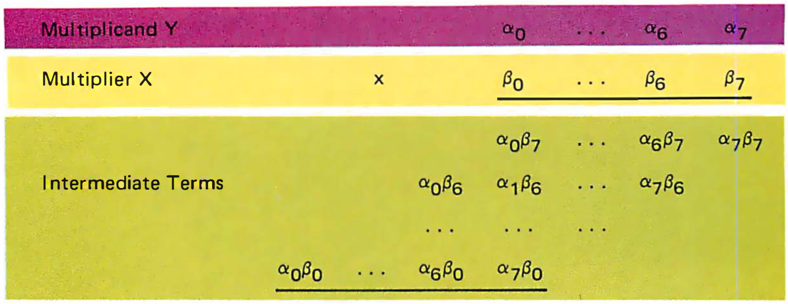
If you do number crunching, then this board is for you. The FPB performs high-speed floating point add, subtract, multiply and divide with selectable precision up to 14 decimal digits. Arithmetic is up to 50 times faster than 8080 software, and BASIC programs can execute up to 10 times faster. A version of North Star BASIC is included. Kit: $259. Assembled: $359. Prices subject to change.

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Figure 3: A full representation of the unsigned multiplication of two binary integers. Note that here we label the most significant bit with 0, the least significant bit with 7 (opposite of the usual designations in many microprocessor functional specifications).



The product is a binary sum of the intermediate terms

```
          801C   FM     EQU    $801C
          801D   SM     EQU    FM+1
          801E   URP    EQU    SM+1
          801F   LRP    EQU    URP+1
     0000 0002   SCTH   RMB    2
     0002 0001   ROWL   RMB    1
     0003 0002   BASE   RMB    2
     0100               ORG    $100
                 *
                 *      SUBROUTINE FETCH4
                 *
                 *      PURPOSE:  FETCH4 LOADS THE INDEX REGISTER
                 *      WITH THE ADDRESS OF T(I,J), WHERE:
                 *
                 *             BASE -- ROW INDEX IN ACCA
                 *                I -- ROW INDEX IN ACCA
                 *                J -- COLUMN INDEX IN ACCB
                 *             ROWL -- ROW LENGTH IN BYTES
                 *             SCTH -- SCRATCH AREA. TWO BYTES
                 *
                 *      RESTRICTIONS:
                 *             ACCA (I) IS DESTROYED
                 *             T MUST HAVE 4 BYTE LONG ELEMENTS
                 *             0 LE I LE 127
                 *             0 LE J LE 30
                 *             ROWL LE 124
                 *             USES SUBROUTINE FETROW
                 *
     0100 8D 0F  FETCH4 BSR    FETROW    GET ROW ADDRESS
     0102 17            TBA              MULTIPLY J
     0103 48            ASL A            BY 4
     0104 48            ASL A
     0105 9B 01         ADD A  SCTH+1    ADD 4*J TO ROW ADDRESS
     0107 97 01         STA A  SCTH+1
     0109 24 C3         BCC    FINFET
     010B 7C 0000       INC    SCTH
     010E DE 00  FINFET LDX    SCTH      LOAD INDEX REGISTER
     0110 39            RTS              AND RETURN
                 *
                 *      SUBROUTINE FETROW
                 *
                 *      PURPOSE:  FETROW LOADS SCRATCH AREA SCTH
                 *      WITH THE ADDRESS OF T(I,0), WHERE:
                 *
                 *             BASE -- TWO BYTE ADDRESS OF T(0,0)
                 *                I -- THE ROW INDEX IN ACCA
                 *             ROWL -- ROW LENGTH IN BYTES
                 *             SCTH -- TWO BYTE SCRATCH AREA
                 *
                 *      RESTRICTIONS:
                 *
                 *             ACCA(I) IS DESTROYED
                 *             0 LE I LE 127
                 *             0 LE ROWL LE 127
                 *             USES HARDWARE MULTIPLIER
                 *
     0111 B7 801C FETROW STA A FM        MULTIPLY ACCA
     0114 96 02         LDA A  ROWL      (CONTAINING I)
     0116 B7 801D       STA A  SM        BY ROW LENGTH
     0119 B6 801F       LDA A  LRP       TO FIND OFFSET
     011C 9B 04         ADD A  BASE+1    ADD TO BASE
     011E 97 01         STA A  SCTH+1    AND SAVE
     0120 B6 801E       LDA A  URP
     0123 99 03         ADC A  BASE
     0125 97 00         STA A  SCTH
     0127 39            RTS              ALL DONE
```

Listing 1: Calculation of address of an element of a matrix T of 4 byte words with given base address and row length. Under 80 machine cycles (counting JSR FETCH4) are required per element. The program can be made even more efficient and general if T is assumed to be aligned on a boundary which is a multiple of 4; a 128 by 128 array can be handled.

dress of each matrix and one of the two dimensions in order to get around. Usually a matrix is stored by rows. In figure 2, we display in full the row-storage order of the 3 by 2 matrix S with hexadecimal base address 100.

If T is an N by M matrix (N rows and M columns) of n byte long elements with base addresses B, then the address A of element T(I,J) is computed as follows:

$$A = B + (I-1) \times M \times n + (J-1) \times n.$$

The numbers M × n and B do not change once the dimension, word length and base location of T are known. The problem of randomly getting around in matrix T is to find A, and this is mostly multiplication. If we assume $M \times n \leqslant 127$ and $N \leqslant 128$, then each product involved in finding A is that of two positive 8 bit two's complement numbers. For instance, if n = 4, this amounts to restricting the maximum dimension of a real matrix to 128 by 31. (Of course, the elements of T could be character strings or bank account numbers; n could even be 1, that is, a byte oriented array. Since our floating point arithmetic uses n = 4, we start with this case.)

Our hardware multiplier forms a 15 bit signed two's complement product after the following, in which FM, SM, URP and LRP are the four successive port addresses of the multiplier:

1. Store the first number to be multiplied in FM.
2. Store the second number in SM.

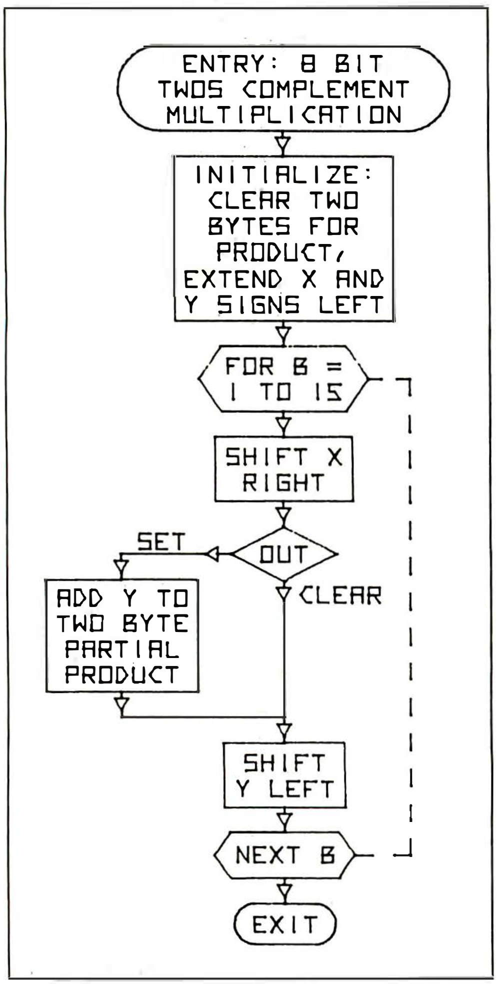
Step 2 causes the multiplication to take place (and does not change the multiplier stored in step 1). We get back the 15 bit product in URP (the Upper Right-shifted Product: 0 plus the first seven bits) and LPR (the Least Right-shifted Product: the low order eight bits).

Suppose T is an N by M matrix of 4 byte quantities with base address in BASE, BASE+1 and the number 4M in ROWL. SCTH is a 2 byte long scratch area. Listing 1, in M6800 assembly language, is a program to

load the index register with the address A where, on entry, the row index is in accumulator A and column index is in accumulator B. (Should, for example, I be unchanged from one fetch to the next, the program can be restructured with an entry point for changing J only.) We think of T as starting at (0,0) instead of (1,1); this replaces I−1 with I and J−1 by J. (This particular program supports the floating point package to be introduced later and is not intended to be very general. For instance, the number 4 could be made variable, allowing access in a three-dimensional array T with dimensions M×N×L; here, L is 4.)

A slightly different approach is better for byte arrays. In listing 2, an up to 128×127 byte array B is accessed by modifying the offset of indexed addressing. Once we find row I we get B(I,J) in ten cycles with

```
     STA B PT+1
PT   LDA A 0,X
```



Algorithm 1: 8 bit two's complement multiplication produces a 14 bit product plus sign bit. This algorithm is coded as a 6800 assembly language program in listing 3.

Listing 2: Subroutine FETCH1; the initialization and required subroutine FETROW are in listing 1. This routine allows byte structured fetch and store in at most 56 cycles. Because the program used modified indexed addressing, it cannot be implemented in ROM.

```
                 *
                 *       SUBROUTINE FETCH1
                 *
                 *       PURPOSE:  FETCH1 LOADS ACCA WITH THE
                 *                 CONTENTS OF B(I,J),WHERE:
                 *
                 *                 BASE -- TWO BYTE ADDRESS OF B(0,0)
                 *                    I -- ROW INDEX IN ACCA
                 *                    J -- COLUMN INDEX IN ACCB
                 *                 ROWL -- ROW LENGTH IN BYTES
                 *                 SCTH -- SCRATCH AREA, TWO BYTES
                 *
                 *       RESTRICTIONS:
                 *
                 *                 ACCA IS DESTROYED
                 *                 0 LE I LE 127
                 *                 0 LE J LE 127
                 *                 ROWL LE 128
                 *                 THE INDEX REGISTER IS RETURNED
                 *                 THE ADDRESS OF B(I,0)
                 *
                 *       USES SUBROUTINE FETROW
0128 8D E7       FETCH1 BSR    FETROW    FIND ROW INDEX
012A DE C0              LDX    SCTH      SAME1 FOR SAME ROW
                 *
                 *                 ENTRY FOR SAME ROW
012C F7 0130     SAME1  STA B  FETCHP+1    MODIFY INDEXED
012F A6 00       FETCHP LDA A  0,X       ADDRESS AND FETCH
0131 39                 RTS
                 *
                 *                 ENTRY FOR STORE ACCA IN B(I,J)
0132 F7 0136     STORE1 STA B  STOREP+1    BE SURE FETROW
0135 A7 00       STOREP STA A  0,X       WAS CALLED FIRST
0137 39                 RTS              SINCE IT KILLS ACCA
                        END
```

Listing 3: A software implementation of what the MPY-8AJ hardware does. More efficient (and more complicated) implementations are possible.

```
                 *
                 *       SUBROUTINE MYP8SO
                 *
                 *       PURPOSE: TO MULTIPLY TWO 8 BIT SIGNED INTEGERS
                 *                GIVING A 14 BIT PLUS SIGN PRODUCT.
                 *                PRODUCT IS RETURNED RIGHT-SHIFTED IN TWO
                 *                SUCCESSIVE BYTES P,P+1
                 *                MULTIPLICANDS ARE IN A,B ON ENTRY.
                 *
0000 00C4        A1     RMB    4
0004 0002        P      RMB    2
0100                    ORG    $100
0100 97 01       MPY8SO STA A  A1+1      INITIALIZE
0102 D7 03              STA B  A1+3
0104 4F                 CLR A
0105 97 C0              STA A  A1        SIGN EXTEND
0107 97 02              STA A  A1+2      AREA ZEROS
0109 97 C4              STA A  P         CLEAR AREA
010B 97 C5              STA A  P+1       FOR PRODUCT
010D 5D                 TST B
010E 2C 03              BGE    BPOSMP
0110 73 0002            COM    A1+2      ONES NOW
0113 7D 0001     BPOSMP TST    A1+1
0116 2C 03              BGE    APOSMP
0118 73 0000            COM    A1        ONES NOW
011B C6 0F       APOSMP LDA B  #15       SET COUNTER
011D 77 0000     LOOPMP ASR    A1        SHIFT X
0120 76 0001            ROR    A1+1      RIGHT
0123 24 0C              BCC    ZEROMP
0125 96 03              LDA A  A1+3      ADD Y TO PRODUCT
0127 9B C5              ADD A  P+1
0129 97 C5              STA A  P+1
012B 96 02              LDA A  A1+2
012D 99 C4              ADC A  P
012F 97 C4              STA A  P
0131 78 0003     ZERCMP ASL    A1+3      SHIFT
0134 79 0002            ROL    A1+2      Y LEFT
0137 5A                 DEC B
0138 26 E3              BNE    LOOPMP    FINISHED?
013A 96 04              LDA A  P         YES.  ZERO BIT 0
013C 84 7F              AND A  #127      OF FIRST WORD
013E 97 C4              STA A  P
0140 39                 RTS
                        END
```

it's a good bet the company you bought your computer from doesn't even make peripherals!

It's no great surprise! Most computer companies got their start in the digital logic end of the business. They were great at building calculators and later computers but when it came right down to it, most just didn't have the experience necessary to build the peripherals to support their computer products. And that left a vacuum!

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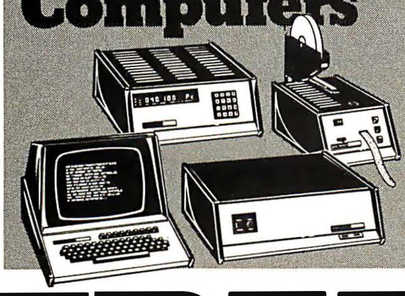
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Circle 53 on inquiry card.

and 22 cycle access (allowing relocatable code) with JSR SAMEI. [*This uses the well-known trick of self-modifying code, and thus will not work if the program is in ROM.*]

The Time Has Come . . .

The preceding section was about addresses, which are positive; the MPY-8AJ does signed arithmetic. Before we show how to use it in multiple precision products (fixed or floating), we need to see how two's complement 8 bit multiplication goes.

Let A be the bit pattern $\alpha_0\alpha_1 \ldots \alpha_7$, B the pattern $\beta_0 \ldots \beta_7$. Were A and B unsigned integers, we could represent the product as shown in figure 3. A few examples show this doesn't work for two's complement numbers if one of A or B turn out to be negative. Not even -1×2 is right: recall $-1 = 11111111$, $2 = 00000010$; the above scheme gives 0000000111111110 (after all

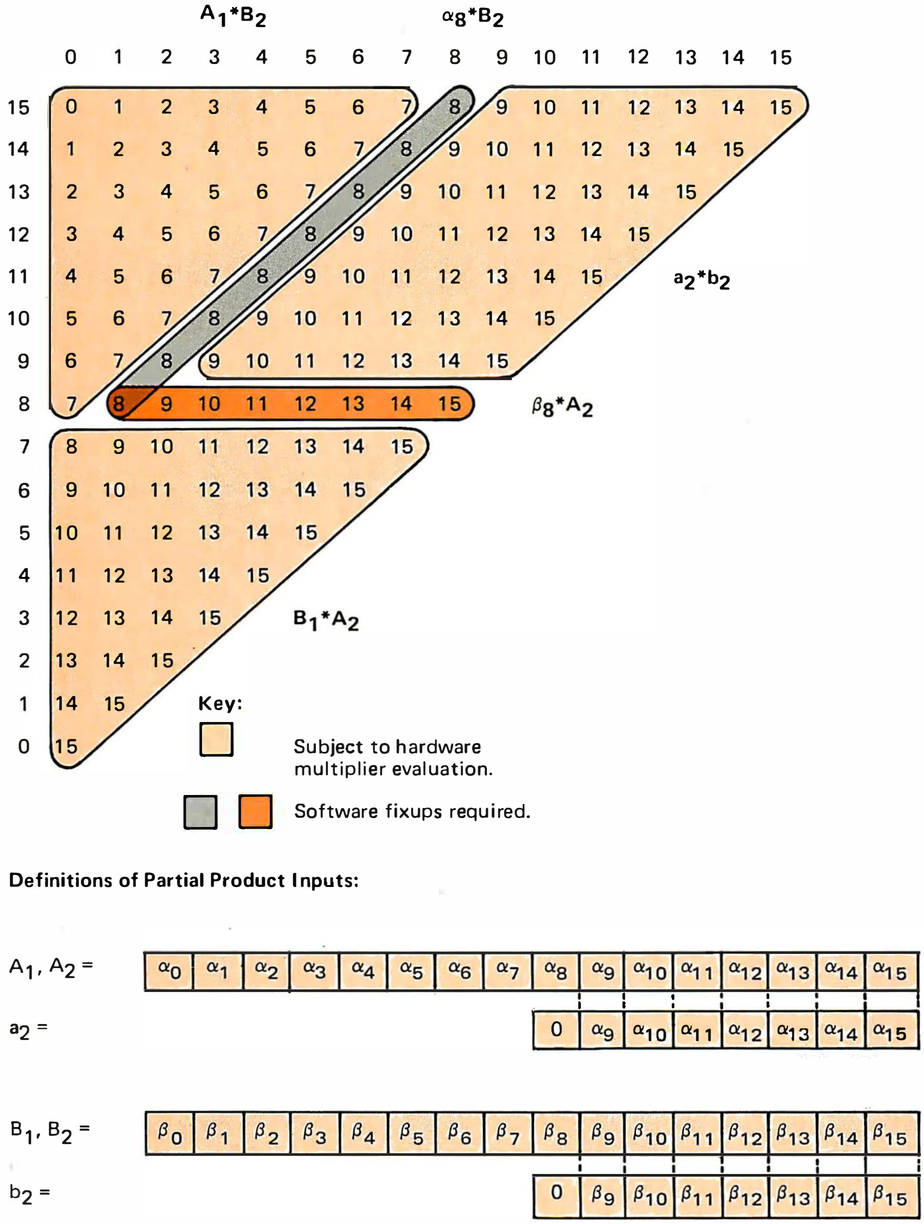


Figure 4: Condensed representation of rightmost 16 bits of the product of two 16 bit two's complement numbers; this is also the same pattern we find in 16 bit unsigned numbers. The headings 0 to 15 along the top represent the bit positions of the sum. The headings 15 to 0 along the side are the subscripts of the bits in B, while entries in the table are subscripts of A. Blocked off in this are parts of the product we can form with a hardware multiplier: a_2b_2 (a 14 bit sum) and the least significant parts of A_1B_2 and B_1A_2. Left over are α_8B_2 and β_8A_2 (but note overlap in which $\alpha_8\beta_8$ is counted twice).

Continued on page 100

Basic systems for personal computing

If you are just getting into personal computing and are looking for a starter system, you have two choices: a computer kit with RAM memory only or a fully assembled computer with BASIC-in-ROM. From reading this magazine and talking to computer buffs it should be obvious that it is desirable to have a computer capable of communicating in the programming language BASIC. This language allows you to instruct the computer in English-like phrases and to use any of the thousands of standard programs written in BASIC (there are probably several in this magazine).

If you purchase a (RAM-only) computer kit you will have to buy additional RAM (4K to 8K), a terminal, and cassette interface for a total cost of about $1000 to run BASIC after you get the kit together and working. Your reward for this endeavor will be a wait of about 15 minutes every time you turn the computer on just to load BASIC into the machine!

Your other alternative is a BASIC-in-ROM computer. These machines have BASIC built in so that it is there whenever the computer is turned on. BASIC-in-ROM computers are also usually fully assembled and cost far less than the RAM-only kits because they are mass-produced by the thousands.

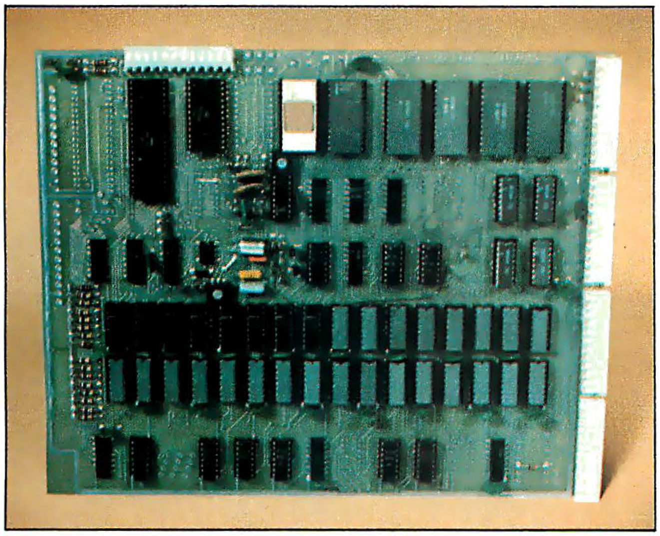
But, you must be careful when selecting a BASIC-in-ROM computer. Some models do not have full-feature BASIC. Instead they have Tiny BASIC or 4K BASIC which cannot run most of the standard BASIC programs available. Still others have other shortcomings such as a small calculator-style keyboard which makes program entry difficult, or most important, lack of expansion capability, preventing the computer from growing with you.

Ohio Scientific offers you a line of expandable computers with full-feature 8K BASIC-in-ROM. They all come fully assembled and tested, but give you the option of economizing by supplying the simple things — power supply, keyboard and TV, if desired, so that you get the most computer power for your dollar.

Compare Ohio Scientific's $298 BASIC-in-ROM Model 500 Board (1MHz clock), which has our Version 3.3 BASIC, against other small computers, as in the independent article "BASIC Timing Comparisons" (Kilobaud, Oct. 1977, p. 23). In this test, the Model 500 excelled over all our personal computing competitors, and was second in performance only to our Challenger disk systems, compared against twenty-eight other computer systems. And the Model 500 is our lowest-cost machine! Our larger models are even more dramatic in a comparison with any competitive models.

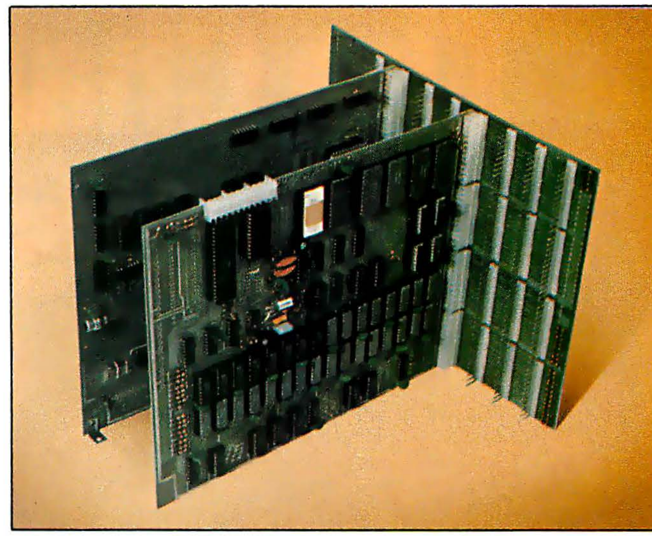
Having the fastest full-feature BASIC ROMs certainly isn't the only criterion necessary for a superior computer system, but it sure helps. Ohio Scientific offers all the other features necessary, including a full line of computer accessories complete with 15 accessory boards available in over 40 configurations. Many Ohio Scientific accessories are so innovative that no one else in the industry has them — such as dual port memory boards, multi-processing CPU's and big disks.

Ohio Scientific has other unique features for the personal computerist. For instance, there is Ohio Scientific's *Small Systems Journal*, published bi-monthly, a full magazine aimed specifically at the owners of Ohio Scientific computers. If you are looking for a personal computer, be sure to look carefully at Ohio Scientific. We think you will find that we have the system for you.



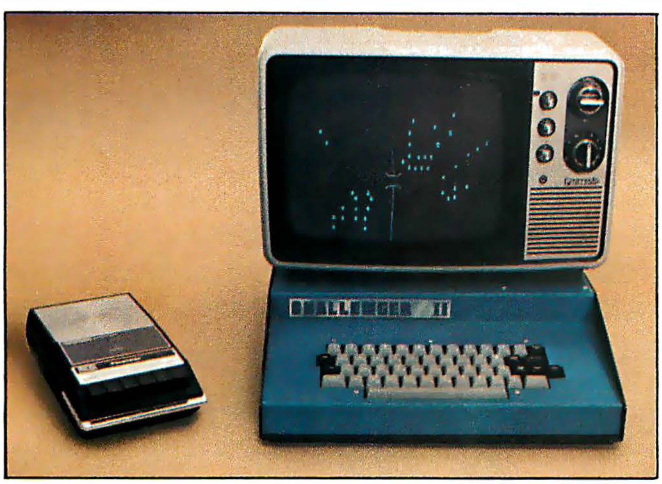
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The ultimate in personal computing offered by Ohio Scientific is the Challenger II system with single- or dual-drive full-sized floppy disk. Each floppy stores 250,000 characters. The Challenger II is available as a video system with keyboard so that all the user needs is a television or monitor for operation; or as a serial version where the user must supply his own terminal. Challenger II disk systems automatically load in BASIC and now have an extensive library of high-performance programs. The programs are ideal for the advanced hobbyist, educational users, industrial development and small business applications. Challenger II disk systems are very economical. For instance, a 16K disk system with 250,000 bytes of disk storage starts at under **$2000.00**

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The Challenger III System

When considering cost effective computers for small business applications, the prospective buyer really has only a few choices: Ohio Scientific's factory-assembled fully integrated computer systems, or the multitude of "pot-luck" 100 systems.

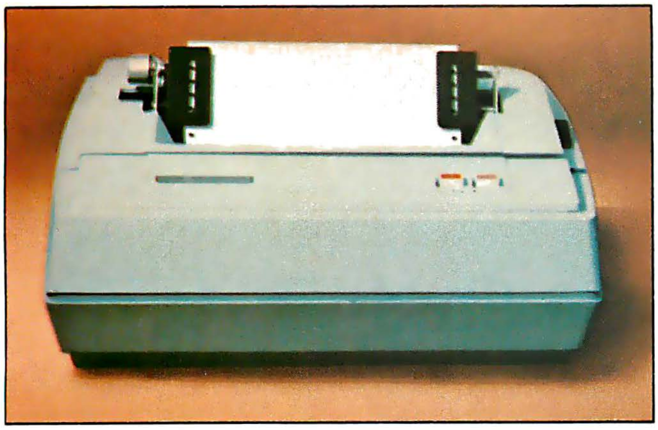
First consider the 100 system. It is a computer system defined as a collection of S-100 components. It is offered by computer stores and systems houses who mix CPU boards, memory boards, cases, mini-floppies, full-size floppies and numerous software packages from many different vendors. In many cases the components even vary from system to system. Unfortunately, what is often used in a computer system is simply what the computer dealer has on hand at the moment. This may include off-brand or obsolete boards, among other things.

The end user of these pot-luck 100 systems may experience dissatisfaction with the system. First of all, all S-100 products are NOT compatible with each other, as is commonly assumed. The same is true for hardware products, and most certainly for software products. So although the user may be able to get one or more software packages from the dealer along with the computer system, it can be a battle from there on converting software to run on his computer.

The second problem is service. If the customer moves or the dealer goes out of business, the customer is out of luck because virtually no one will service computer systems of mixed origin. The computer system might even have been built from kits since most S-100 manufacturers offer their products in kit form. Several charge outrageous prices for assembled products. And then there is future expansion — this can be difficult because all S-100 products are not created equal or compatible!

We could go on with this horror story, but let us take a more positive approach and look at the other alternative — the factory-integrated computer system. Ohio Scientific manufactures a full line of computers and accessories which are not compatible with S-100 equipment, but are fully compatible with our full line of expansion accessories. All of our systems-level equipment has always been available only in fully assembled form. When you buy an OSI small business system from a dealer, you are assured of buying a standard computer system that was factory assembled and tested. You can be assured of getting service from any of Ohio Scientific's dealers and direct from the factory, now and in the future, whether you stay in your present location or move across the country.

A standardized system means standard software. You can order any of Ohio Scientific's library of diskettes, put them in your disk drive, and your system will perform immediately. And you can make use of our large dealer-generated software library which runs on all Ohio Scientific disk systems. Finally, regardless of the possible pitfalls with other computer systems, Ohio Scientific's Challenger II and Challenger III business systems stand on their own, based on ultra-high performance and impressive performance/cost ratio. Look carefully at the specifications of the Challenger III system on the following page. Compare the advantages of a factory-integrated and supported computer system with those of a computer system of mixed origin. We think you will agree Ohio Scientific is the only sensible choice in cost-effective small business computing.







- Designed for small business computing.
- Uses the 510 triple processor CPU Board, runs 6502, 6800, 8080 and Z-80 programs.
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Optimization: A Case Study

William B Noyce
31 Cathy St
Merrimack NH 03054

Whatever size computer one works with, there is usually pressure to make it perform a given task in less time or less memory. "Optimization" techniques are methods for accomplishing such speed or memory improvements. Usually the most effective changes to a program are "algorithmic changes," changes to the strategy the program uses to get its result. An algorithmic change can reduce the time a program takes to run by 50 to 90 percent. For example, using the well-known quicksort or heapsort instead of a bubble sort to sort long lists can have this effect.

Sometimes, however, significant results can be achieved by "coding changes," in which the modified program does essentially the same thing as the previous version, but in a better way. Most compilers perform optimizations of this type, such as keeping in a register any expression whose value is used more than once, rather than recomputing it whenever it is needed. Coding changes often exploit simple mathematical or logical identities.

This article follows through the step-by-step processes used to reduce by about 25 percent the time and space taken by a small subroutine. The example subroutine is the "Novel 8 Bit Multiplication" by Christopher D Glaeser (July 1977 BYTE, page 142), which is reproduced in listing 1.

Coding changes are not effective at reducing the time taken by a program unless they are applied to the most heavily used parts of the program. If some part only accounts for 2 percent of the time used by the program, no optimizations applied only to this part can speed up the program by more than 2 percent. Usually, the most heavily used parts of a program are inside commonly used subroutines or deeply nested loops.

The 8 instruction loop starting at LOOP in listing 1 accounts for about 80 percent of the time in the multiply subroutine. The loop works by testing, from right to left, bits of the number passed in C, and adding the number passed in D to the appropriate position on the partial product. The number whose bits are tested is called the multiplier, and the number that is added is called the multiplicand. The partial product is kept in HL, because it accumulates a 16 bit sum. Since the multiplicand needs to shift left, it is kept in DE, and the XCHG instruction moves it into HL to be shifted. If we can eliminate the need to shift the multiplicand we can save the XCHG instructions and a little setup code.

The original loop computes:

$$2^0P_0 + 2^1P_1 + 2^2P_2 + 2^3P_3 + 2^4P_4 + 2^5P_5 + 2^6P_6 + 2^7P_7$$

where P_i = the multiplicand if bit i of the multiplier is 1, or 0 if the bit is 0. This expression is equivalent, by the distributive law, to:

$$((((((P_7 \cdot 2 + P_6) \cdot 2 + P_5) \cdot 2 + P_4) \cdot 2 + P_3) \cdot 2 + P_2) \cdot 2 + P_1) \cdot 2 + P_0.$$

About the Author

Author William B Noyce is 23 years old. For four and a half years he has worked as a systems programmer for the Dartmouth Time Sharing System, and is currently a Software Engineer at Digital Equipment Corp. At home he has an 8080 based microcomputer on which he hopes to develop a high level language compiler and a powerful graphics system.



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PolyMorphic Systems

```
LOC  OBJ        SOURCE STATEMENT

                ; MULTIPLY C BY D, GIVING BC.
                ; PRESERVES D,E,H,L.
                ;
                ; ORIGINAL PROGRAM BY CHRISTOPHER D GLAESER
                ; COPYRIGHT 1977 BY BYTE PUBLICATIONS, INC.
                ;
                ; 27 BYTES, ABOUT 512 CYCLES.
                ;

0000 D5         MULT1:  PUSH D          ; SAVE REGISTERS
0001 E5                 PUSH H
0002 5A                 MOV E,D         ; MOVF MULTIPLICAND TO DE (LOWER)
0003 1600               MVI D,0         ; AND CLEAR DE (UPPER)
0005 6A                 MOV L,D         ; CLEAR PRODUCT AREA
0006 62                 MOV H,D
0007 0608               MVI B,8         ; LOOP COUNTER
0009 79                 MOV A,C         ; PUT MULTIPLIER WHERE IT CAN SHIFT

000A 1F         LOOP1:  RAR             ; TEST NEXT MULTIPLIER BIT
000B D20F00             JNC SKIP1
000E 19                 DAD D           ; ADD MULTIPLICAND
000F EB         SKIP1:  XCHG            ; SWAP DE WITH HL
0010 29                 DAD H           ; SHIFT MULTIPLICAND LEFT
0011 EB                 XCHG            ; SWAP BACK
0012 05                 DCR B
0013 C20A00             JNZ LOOP1       ; REPEAT 8 TIMES

0016 44                 MOV B,H         ; MOVE PRODUCT TO BC
0017 4D                 MOV C,L
0018 E1                 POP H           ; RESTORE REGISTERS
0019 D1                 POP D
001A C9                 RET             ; RETURN

                $ EJECT
```

Listing 1: The starting point for this case study in optimization is a routine by Christopher D Glaeser, which appeared in July 1977 BYTE on page 142. This listing reproduces Christopher's multiplication algorithm, which takes 27 bytes of memory and about 512 cycles of the processor clock.

```
LOC  OBJ        SOURCE STATEMENT

                ; MULTIPLY C BY D, GIVING BC.
                ; PRESERVES D,E,H,L.
                ;
                ; SHIFT PRODUCT INSTEAD OF MULTIPLICAND.
                ; SHIFT MULTIPLIER LEFT INSTEAD OF RIGHT.
                ;
                ; 25 BYTES, ABOUT 448 CYCLES.
                ;

001B D5         MULT2:  PUSH D          ; SAVE REGISTERS
001C E5                 PUSH H
001D 5A                 MOV E,D         ; MOVE MULTIPLICAND TO DE (LOWER)
001E 1600               MVI D,0         ; AND CLEAR DE (UPPER)
0020 6A                 MOV L,D         ; CLEAR PRODUCT AREA
0021 62                 MOV H,D
0022 0608               MVI B,8         ; LOOP COUNTER
0024 79                 MOV A,C         ; PUT MULTIPLIER WHERE IT CAN SHIFT

0025 29         LOOP2:  DAD H           ; SHIFT PRODUCT LEFT
0026 17                 RAL             ; TEST MEXT MULTIPLIER BIT
0027 D22B00             JNC SKIP2
002A 19                 DAD D           ; ADD MULTIPLICAND
002B 05         SKIP2:  DCR B
002C C22500             JNZ LOOP2       ; REPEAT 8 TIMES

002F 44                 MOV B,H         ; MOVE PRODUCT TO BC
0030 4D                 MOV C,L
0031 E1                 POP H           ; RESTORE REGISTERS
0032 D1                 POP D
0033 C9                 RET             ; RETURN

                $ EJECT
```

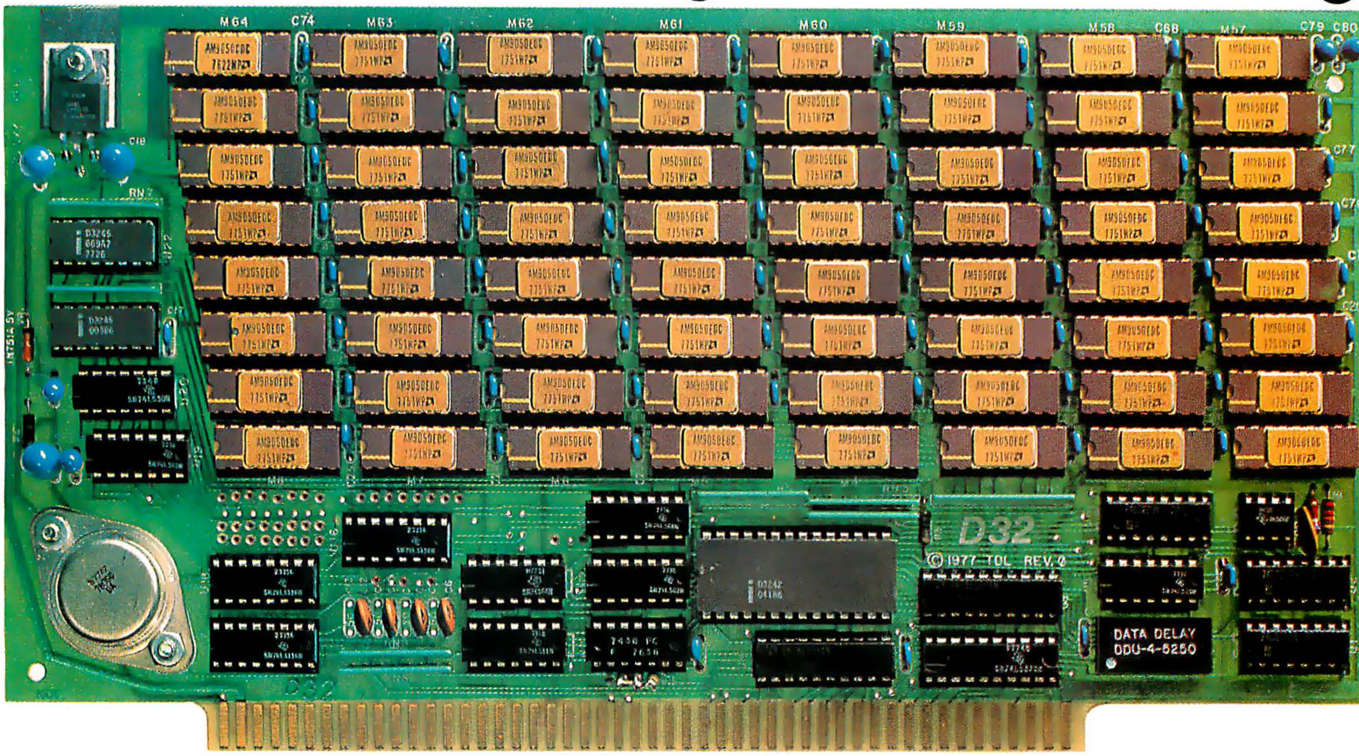
Listing 2: By rearranging the code of the inner loop so that an equivalent operation is performed, some time can be saved. This (for an 8080) involves changing the order of shifting of the multiplier, and using a double precision addition operation as the equivalent of a shift. This modified routine takes 25 bytes and executes in about 448 cycles.

This latter expression shows how we can shift the product left after every addition except the last, if we always add the multiplicand into the lower byte. If we added the multiplicand into the upper byte, we could shift the product to the right after every addition, but the 8080 has no 16 bit right shift instruction. The change to shift the product left requires that we examine the leftmost multiplier bits first: the new inner loop appears in listing 2. Note that the product is shifted at the beginning of the loop; this is so it doesn't get shifted after the last time through.

Since the product is shifted left eight times, there is no need to clear its upper half initially with a MOV H, D instruction. Whatever garbage is in H will be shifted off and have no effect on the subroutine's result. But we can put these unused bits to work instead of wasting them. After n times through the loop there are $8 - n$ bits remaining in the multiplier and $8 - n$ unused bits in H, since the partial product occupies only $8 + n$ bits. The product and multiplier can coexist peacefully in HL, and every time the product is shifted, a bit of the multiplier falls out into the carry. We can thus eliminate the RAL instruction which shifted multiplier bits into the carry. The new subroutine appears in listing 3.

Where else can we save time or space? The user of the original subroutine obviously didn't care whether the input values of registers A and C were preserved, but we don't use them in the loop. We can save time and space by using these registers. Instead, program 3 uses B, D and E, and saves input values of D and E on the stack. Register pair DE was used as the multiplicand because we needed to use XCHG; DAD H; XCHG to shift it, but we no longer shift the multiplicand. Because we want our multiplicand in the lower byte of a register pair, we should use the number passed in C as the multiplicand and the number passed in D as the multiplier. This is legal because of the commutative law. Effectively, we save the MOV E, D which moves the multiplicand to the lower half of its register pair, and other instructions are changed. We can keep the loop counter in A, which is no longer needed for the multiplier. Now the subroutine no longer modifies D or E, so the PUSH D and POP D instructions may be deleted. The savings in stack space may or may not be important, depending on other parts of the program in which the subroutine appears, but there is a significant saving in time and program size. The final version of the subroutine appears in listing 4. It is 20 bytes

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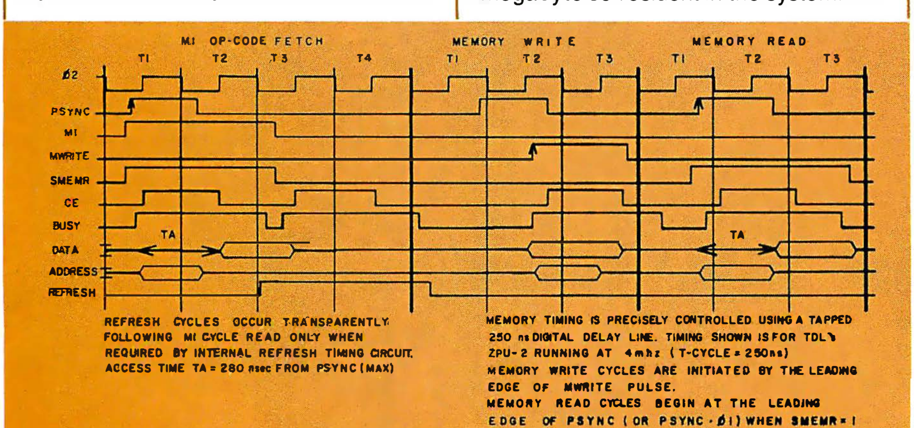
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TECHNICAL DESIGN LABS

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Listing 3: Having made the modifications of listing 2, the upper half of the HL register pair can initially contain arbitrary data. By actually using the most significant bits of HL, the product and multiplier can both be kept in this one register in a new version of the routine which takes 23 bytes and about 411 clock cycles.

```
LOC  OBJ                SOURCE STATEMENT

                  ;MULTIPLY C BY D, GIVING BC.
                  ; PRESERVES D,E,H,L.
                  ;
                  ; KEEP MULTIPLIER AND PRODUCT TOGETHER IN HL.
                  ; 23 BYTES, ABOUT 411 CYCLES.
                  ;

0034 D5           MULT3:  PUSH D          ; SAVE REGISTERS
0035 E5                   PUSH H
0036 5A                   MOV E,D         ; MOVE MULTIPLICAND TO DE (LOWER)
0037 1600                 MVI D,0         ; AND CLEAR DE (UPPER)
0039 6A                   MOV L,D         ; CLEAR LOW PRODUCT AREA
003A 61                   MOV H,C         ; MOVE MULTIPLIER TO HIGH PRODUCT AREA
003B 0608                 MVI B,8         ; LOOP COUNTER

003D 29           LOOP3:  DAD H           ; SHIFT MULTIPLIER AND PRODUCT LEFT
003E D24200               JNC SKIP3       ; TEST A MULTIPLIER BIT
0041 19                   DAD D           ; ADD MULTIPLICAND
0042 05           SKIP3:  DCR B
0043 C23D00               JNZ LOOP3       ; REPEAT 8 TIMES

0046 44                   MOV B,H         ; MOVE PRODUCT TO BC
0047 4D                   MOV C,L
0048 E1                   POP H           ; RESTORE REGISTERS
0049 D1                   POP D
004A C9                   RET             ; RETURN

                  $ EJECT
```

Listing 4: By doing "the great register shuffle," further improvement can be accomplished by passing parameters in registers. This version chips away at time requirements and requires only 385 cycles, with 20 bytes of code.

```
LOC  OBJ                SOURCE STATEMENT

                  ; MULTIPLY C BY D, GIVING BC.
                  ; PRESERVES D,E,H,L.
                  ;
                  ; THE GREAT REGISTER SHUFFLE.  MULTIPLICAND IS IN BC,
                  ; MULTIPLIER IN H, AND LOOP COUNTER IN A.  DE IS NOT USED.
                  ;
                  ; 20 BYTES, ABOUT 385 CYCLES.
                  ;

004B E5           MULT4:  PUSH H          ; SAVE REGISTERS
004C 0600                 MVI B,0         ; CLEAR MULTIPLICAND HIGH BYTE
004E 68                   MOV L,B         ; CLEAR PRODUCT LOW BYTE
004F 62                   MOV H,D         ; MOVE MULTIPLIER TO HIGH PRODUCT AREA
0050 3E08                 MVI A,8         ; LOOP COUNTER

0052 29           LOOP4:  DAD H           ; SHIFT MULTIPLIER AND PRODUCT LEFT
0053 D25700               JNC SKIP4       ; TEST A MULTIPLIER BIT
0056 09                   DAD B           ; ADD MULTIPLICAND
0057 3D           SKIP4:  DCR A
0058 C25200               JNZ LOOP4       ; REPEAT 8 TIMES

005B 44                   MOV B,H         ; MOVE PRODUCT TO BC
005C 4D                   MOV C,L
005D E1                   POP H           ; RESTORE REGISTERS
005E C9                   RET             ; RETURN

                  $ EJECT
```

Listing 5: After virtually exhausting straightforward improvements of the looping methods, the only further improvements possible come from unrolling the loop into larger amounts of program memory. This version partially unrolls the multiplication loop, takes 28 bytes of memory and about 325 cycles.

```
LOC  OBJ                SOURCE STATEMENT

                  ; MULTIPLY C BY D, GIVING BC.
                  ; PRESERVES D,E,H,L.
                  ;
                  ; LOOP IS PARTIALLY UNROLLED.
                  ;
                  ; 28 BYTES, ABOUT 325 CYCLES.
                  ;

005F E5           MULT5:  PUSH H          ; SAVE REGISTERS
0060 0600                 MVI B,0         ; CLEAR MULTIPLICAND HIGH BYTE
0062 68                   MOV L,B         ; CLEAR PRODUCT LOW BYTE
0063 62                   MOV H,D         ; MOVE MULTIPLIER TO HIGH PRODUCT AREA
0064 3E04                 MVI A,4         ; LOOP COUNTER (HALF NORMAL SIZE)

0066 29           LOOP5:  DAD H           ; SHIFT MULTIPLIER AND PRODUCT LEFT
0067 D26B00               JNC SKIP5A      ; TEST A MULTIPLIER BIT
006A 09                   DAD B           ; ADD MULTIPLICAND
006B 29           SKIP5A: DAD H           ; -- REPEAT LOOP AGAIN --
006C D27000               JNC SKIP5B
006F 09                   DAD B
0070 3D           SKIP5B: DCR A
0071 C26600               JNZ LOOP5       ; REPEAT 4 TIMES

0074 44                   MOV B,H         ; MOVE PRODUCT TO BC
0075 4D                   MOV C,L
0076 E1                   POP H           ; RESTORE REGISTERS
0077 C9                   RET

                  $ EJECT
```

```
LOC  OBJ       SOURCE STATEMENT

                ;MULTIPLY C BY D, GIVING BC.
                ; PRESERVES D,E,H,L.
                ;
                ; LOOP IS FULLY UNROLLED.
                ;
                ; 49 BYTES, ABOUT 258 CYCLES.
                ;
0078 E5         MULT6:  PUSH H          ; SAVE REGISTERS
0079 0600               MVI B,0         ; CLEAR MULTIPLICAND HIGH BYTE
007B 58                 MOV L,B         ; CLEAR PRODUCT AREA LOW BYTE
007C 52                 MOV H,D         ; MOVE MULTIPLIER TO PRODUCT AREA HIGH BYTE
007D 29                 DAD H           ; SHIFT MULTIPLIER AND PRODUCT LEFT
007E D28200             JNC SKIP6A      ; TEST A MULTIPLIER BIT
0081 19                 DAD D           ; ADD MULTIPLICAND
0082 29         SKIP6A: DAD H           ; -- REPEAT LOOP 7 MORE TIMES --
0083 D28700             JNC SKIP6B
0086 19                 DAD D
0087 29         SKIP6B: DAD H
0088 D28C00             JNC SKIP6C
008B 19                 DAD D
008C 29         SKIP6C: DAD H
008D D29100             JNC SKIP6D
0090 19                 DAD D
0091 29         SKIP6D: DAD H
0092 D29600             JNC SKIP6E
0095 09                 DAD B
0096 29         SKIP6E: DAD H
0097 D29B00             JNC SKIP6F
009A 09                 DAD B
009B 29         SKIP6F: DAD H
009C D2A000             JNC SKIP6G
009F 09                 DAD B
00A0 29         SKIP6G: DAD H
00A1 D2A500             JNC SKIP6H
00A4 09                 DAD B
                SKIP6H:                 ; -- END OF UNROLLED LOOP --
00A5 44                 MOV B,H         ; MOVE PRODUCT TO BC
00A6 4D                 MOV C,L
00A7 E1                 POP H           ; RESTORE REGISTERS
00A8 C9                 RET
                        END
```

Listing 6: Perhaps the ultimate 8 by 8 bit multiply short of a memory intensive full table lookup of answers is this fully unrolled version which expands the memory requirements to 49 bytes, but cuts the time requirement to 258 cycles for nearly 50 percent savings relative to the time requirement of the original program.

long, compared with 27 for the original routine, and takes about 393 cycles, compared with about 525 cycles for the original routine. A million multiplications with a typical 8080 processor's clock would take about four minutes, 20 seconds with the old version and about three minutes, 15 seconds with the new.

If this isn't fast enough, we can speed up the routine still further, by "unrolling" the loop, replicating its instructions as shown in listings 5 and 6. This eliminates some or all of the time taken by the DCR A and JNZ LOOP instructions which control the looping. In listing 5 the loop control is only executed four times instead of eight, and in listing 6 there is no loop control at all. These speedup techniques cost memory, however, and tend to make the code more confusing. It is common to have to trade memory for speed, and which is more important depends on the particular program. With the long program, our million multiplications would take only about two minutes, 13 seconds, just over half as long as the original program.■

Hand Assembling M6800 Relative Addresses

Ray Boaz
1516 Jarvis Pl
San Jose CA 95118

M6800 BRANCH ADDRESS CALCULATOR TABLE

MSH – B	F	E	D	C	B	A	9	8	
LSH – B									LSH – F
—	—	16	32	48	64	80	96	112	0
F	1	17	33	49	65	81	97	113	1
E	2	18	34	50	66	82	98	114	2
D	3	19	35	51	67	83	99	115	3
C	4	20	36	52	68	84	100	116	4
B	5	21	37	53	69	85	101	117	5
A	6	22	38	54	70	86	102	118	6
9	7	23	39	55	71	87	103	119	7
8	8	24	40	56	72	88	104	120	8
7	9	25	41	57	73	89	105	121	9
6	10	26	42	58	74	90	106	122	A
5	11	27	43	59	75	91	107	123	B
4	12	28	44	60	76	92	108	124	C
3	13	29	45	61	77	93	109	125	D
2	14	30	46	62	78	94	110	126	E
1	15	31	47	63	79	95	111	127	F
0	16	32	48	64	80	96	112	—	—
	0	1	2	3	4	5	6	7	MSH – F

1. Count the number of bytes (in decimal) from the instruction following the branch to the branch target instruction.
2. Find this number inside the table.
3. Read the hexadecimal equivalent.
   a. Top and left for branching backward.
   b. Bottom and right for branching forward.

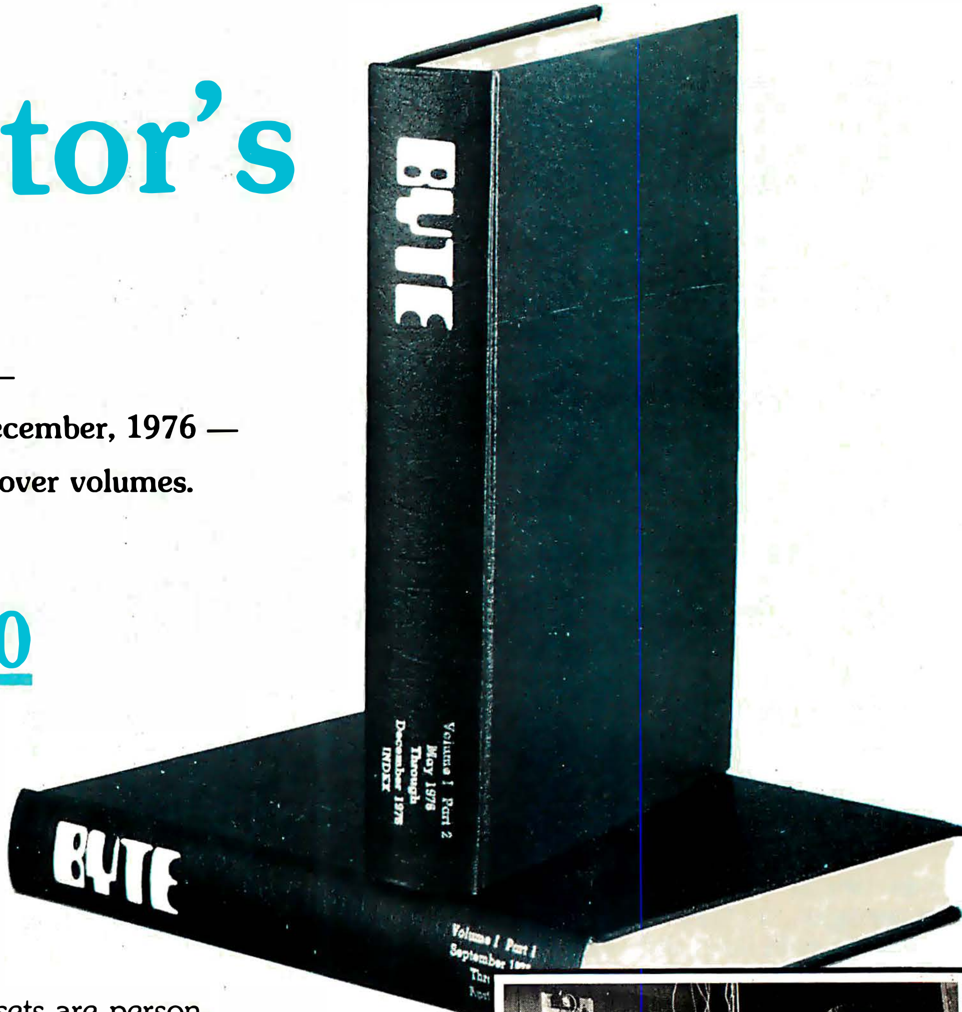
The "hand assembler" is the only resident assembler many of us have, and as such it is the means to an end in homebrew computing. However, this is really *the* way to learn your computer's instruction set. In March 1976 BYTE Carl Helmers pointed out the big problem of calculating the relative address for branching used in M6800 microcomputer systems. This problem is real and anyone using the M6800 runs into it when hand assembling a program.

The range of branch instructions for the M6800 is 125 bytes before the value of the program counter (PC) to 127 bytes after the value of the program counter. Using the instruction following the branch instruction as the starting point, count the number of bytes, in decimal, forward or backward, to the instruction being branched to. Find this decimal number inside the table. Read the hexadecimal equivalent at the top and left side for branching backward, or at the bottom and right side for branching forward. This hexadecimal equivalent is the branch operand, which in this case is the value added to the program counter.

This technique is much easier and faster than either adding and subtracting in hexadecimal, or counting forward and backward in hexadecimal. A few examples are back 4_{10} bytes = FC_{16}, forward 42_{10} bytes = $2A_{16}$, and back 110_{10} bytes = 92_{16}.■

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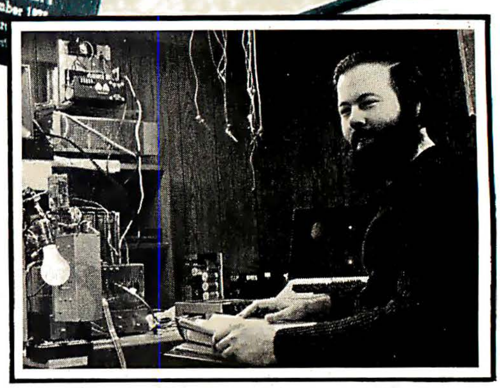
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Photo 1: A view of the complete TRS-80 computer with the Radio Shack supplied video monitor and audio cassette recorder, supplied courtesy of Radio Shack. Priced at $599.95 for a 4 K byte version, this personal computer includes a BASIC interpreter and cassette interface software in 4 K bytes of read only memory. This is a BASIC only machine. The user cannot gain access to the machine language of the Z-80 processor which runs the BASIC interpreter.

The Radio Shack TRS-80: An Owner's Report

Dan Fylstra
22 Weitz St #3
Boston MA 02134

Photography by Dan Comly

On August 3 1977, the Radio Shack division of Tandy Corporation announced its entry into the personal computing market with the TRS-80 microcomputer. The move held special significance for the personal computing industry, for with parent company sales of nearly a billion dollars and over 6000 retail stores including 500 overseas, Radio Shack is in a unique position to help bring personal computers to the average man or woman.

The TRS-80 is an "appliance" computer, preassembled and warrantied with a built-in BASIC language interpreter, and at a price of under $600 it will be affordable by many new personal computing enthusiasts. But $600 still represents a major investment for most of us, and it's desirable to know as much as possible about the detailed specifications of a computer before buying one. If you're contemplating purchase of one of the "appliance" computers now on the market, this review should be helpful to you in making your evaluation.

I ordered a TRS-80 the day after Radio Shack's press announcement, and hence I received one of the early units without a complete user's manual or any technical information on the TRS-80's provisions for expansion. Radio Shack has announced plans to introduce several significant hardware and software extensions to the basic TRS-80, some of which may become available before this article appears in print. As you read this, bear in mind that it was written in late October 1977, based on the somewhat limited information available at that time.

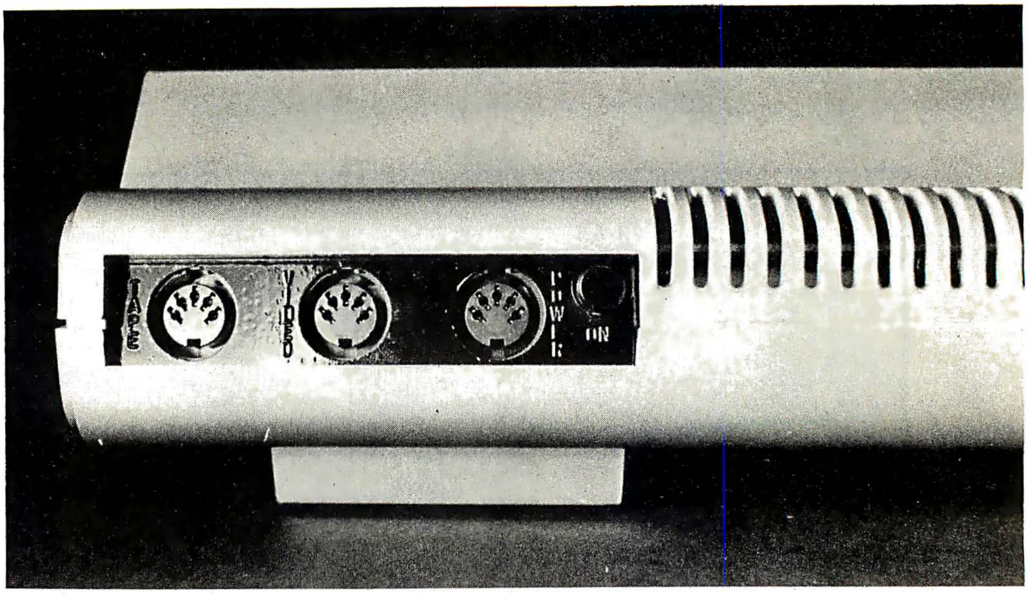


Photo 2: This back view of the TRS-80 processor unit shows the three 5 pin DIN type connectors used to attach the power supply, video monitor and cassette recorder. DIN connectors are commonly used in the audio component field, and are available at most Radio Shack retail outlets. If the complete system of photo 1 is purchased, all necessary cables are supplied.

General Specifications

Photo 1 illustrates the complete TRS-80 package, consisting of the keyboard which houses the microcomputer and memory, a video monitor, an audio cassette recorder and a power supply. The keyboard unit measures 16.5 by 8 by 3.5 inches (41.9 by 20.3 by 8.9 cm) and is very portable. The entire package including the video monitor and cassette recorder is a lot to carry, but I did take the entire computer with me on one half mile walk from the Boston home of Radio Shack to my apartment.

The components of the TRS-80 are easily plugged together using standard 5 pin DIN type audio connectors and cords which are supplied with the complete package. Jacks for the power supply, video monitor and cassette recorder are mounted on the back side of the keyboard unit, as illustrated in photo 2. For the experimenter, the DIN type plugs and jacks are available (you guessed it) as a stock item in most Radio Shack stores.

The video monitor and cassette recorder are standard items, and if you already own one or both of these you can probably use them with the TRS-80 to save on your investment. I actually bought only the keyboard unit for $400 and attached it to a Radio Shack CTR-35 cassette recorder which I already owned, and a Hitachi TV set modified for direct video entry using the Pickles & Trout kit. My home setup is shown in photo 3. The cassette recorder you use should have "earphone" and "auxiliary input" jacks and a "remote" jack for starting and stopping the cassette drive motor. The connection cords for the cassette recorder are supplied with the keyboard unit. The video monitor or TV set should accept a direct video signal (EIA standard, 75 ohm input) rather than a radio frequency (RF) signal generated by a modulator in order to provide the bandwidth required for the TRS-80's display. For the prospective buyer who doesn't already own this sort of equipment or who doesn't possess the special skills needed to modify a TV set, the complete TRS-80 package includes the video monitor and cassette recorder.

Inside the TRS-80's keyboard unit are 4 K bytes of read only memory containing Radio Shack's Level I BASIC interpreter as well as software to control the cassette recorder and display screen, and 4 K bytes of programmable memory which holds the user's BASIC program. The eight integrated circuit chips inside the unit which provide the 4 K bytes of programmable memory can be replaced by higher density memory chips to provide 8 K or 16 K bytes of memory inside the basic keyboard unit. Similarly, the two chips which provide 4 K bytes of read only memory can be replaced by higher density chips to provide 8 K or 12 K bytes of read only memory, enough to hold a much more powerful BASIC language interpreter and disk operating system which are said to be planned for later introduction.

Radio Shack has priced separately every component and memory option in the TRS-80 system. The microcomputer with keyboard and 4 K bytes of user memory is $399.95; the video monitor is priced at $199.95; and the CTR-41 cassette recorder is $49.95. These components can be purchased as a complete package deal for $599.95. An additional 4 K bytes of programmable memory for a total capacity of 8 K is priced at $99.95, while an additional 12 K bytes of memory for a total capacity

of 16 K is priced at $289.95. For planning purposes it is important to note that there is no "trade-in allowance" on the lower density memory chips if the user decides to expand to the higher density chips. Thus it would not make sense to order the TRS-80 now with 8 K bytes of memory if the owner later intended to expand to 16 K bytes (which will probably be necessary to support the future disk operating system) since the total outlay for 16 K bytes of memory would then be $389.90.

BASIC programs in memory are stored in character form rather than encoded form, but abbreviations for most of the BASIC keywords are provided to save space. Thus you can write P. instead of PRINT and G. instead of GOTO, and thereby save a considerable amount of memory space since these keywords occur so frequently in a large program.

The TRS-80 is based on the Z-80 microprocessor, but this fact is really only important from the standpoint of designing and implementing the computer's read only memory software. At present the TRS-80 user is "insulated" from the hazards (and pleasures) of programming the Z-80 directly, since the BASIC interpreter is automatically activated when power is turned on, and there is no way at present to drop into machine language.

Display Screen

The TRS-80 includes a 12 inch (30.5 cm) black and white, high resolution video monitor which presents 1024 characters, arranged in 16 lines of 64 characters each. (The display is said to be "software selectable" for 32 or 64 characters per line, but no documentation is available at this writing on how the selection is made.) The display is memory mapped (ie: continuously read out of a section of programmable memory separate from the BASIC program and data memory), and is easily controlled from BASIC for both alphabetic and graphic displays.

Built-in software provides an underline cursor and automatic scrolling from the bottom of the display. The keyboard includes four keys to move the cursor in any direction, but present software supports only the "cursor left" key which deletes the character



Photo 3: The author's home setup showing the TRS-80 processor unit with its keyboard, connected to an ordinary Hitachi television set modified for direct video entry using a kit from Pickles & Trout, POB 2276, Goleta CA 93018. This setup permits conventional program reception on the television and saves about $100 over the price of the complete Radio Shack system; but it requires some electronics skill in order to modify the television set. Use of this television set and modification kit is further described in the article "Convert Your TV Set to a Video Monitor" which will appear in a forthcoming issue of BYTE.

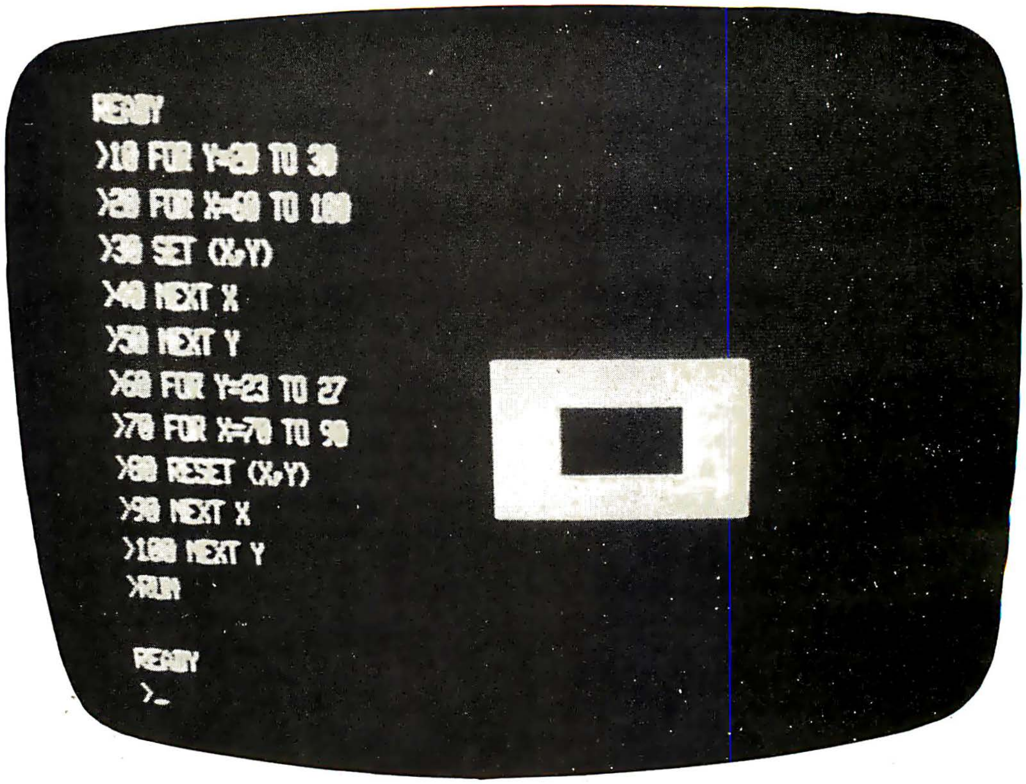


Photo 4: An illustration of the use of the TRS-80's graphics capabilities. The BASIC program shown on the screen created the square and cutout by using the SET and RESET statements to turn points on and off. This illustrates the arbitrary way in which text and graphics can be interspersed on the display.

or characters just entered on the current line. (The cursor can be moved to arbitrary positions under BASIC program control, as described below.) The "cursor up" key is used to continue a line by line listing of a program which has already filled the display screen. Another key is provided to clear the screen.

Character Set and Graphics

The TRS-80's character set consists of 58 characters including upper case alphabetic and various numeric and special characters. In addition, each character position on the screen is divided into six tiny squares, two across and three down, and each of these squares can be set on (white) or off (black) under program control. Thus graphic displays with a resolution of 128 by 48 points can be created on the screen.

The BASIC language features for controlling the graphic display are especially convenient. A point can be turned on with a statement of the form SET (X,Y), where X ranges from 0 to 127 and Y ranges from 0 to 47, or turned off with the statement RESET (X,Y). The function POINT (X,Y) can be used in an IF statement to determine whether a particular point on the display is currently on or off. Besides the graphic point addressing, the 1024 character positions on the screen are numbered sequentially from left to right, line by line, and the cursor can be set to an arbitrary position with a statement such as PRINT AT Z, "EXAMPLE MESSAGE", A+B, where Z varies between 0 and 1023. Thus displayed messages, which can be interspersed with graphics, are easily placed at any position on the screen. Finally, the CLS statement in BASIC can be used to clear the screen.

Photo 4 provides a simple illustration of the use of the TRS-80's graphics capabilities. The BASIC program shown on the screen created the graphic display by first filling in a solid square with the SET statement, and they blanking out the inner square cutout with the RESET statement. A variety of simple pictures could be drawn in this manner. The TRS-80's graphics features are especially convenient for plotting data or mathematical functions, due to the ability to address single points on the display.

Keyboard

The TRS-80's keyboard includes 53 keys with the standard spacing and arrangement used on a typewriter keyboard. It is well-suited for touch typing and will be quite familiar to the experienced user of the Teletype terminals found on timesharing systems and minicomputers. The keys are of the mechanical contact type, and they have a reasonably good "feel" and seem quite reliable in use. A BASIC program can read numeric quantities and character strings from the keyboard with the INPUT statement, which allows a message to be displayed at the same time, as in INPUT "ENTER STARTING VALUE";X.



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Statements	LET	GOTO	REM
	READ	IF ... THEN	RUN
	DATA	FOR ... TO ... STEP	CONT
	RESTORE	NEXT	NEW
	PRINT	GOSUB	LIST
	INPUT	RETURN	
		ON ... GOTO	
		ON ... GOSUB	
		STOP	
		END	
Operators	=	=	
	+	< >	
	–	< =	
	*	> =	
	/	<	
		>	
Built-in Functions	ABS	MEM	
	INT	TAB	
	RND		
Other Features	CLOAD	CLS	PRINT AT
	CSAVE	SET	INPUT#
		RESET	PRINT#
		POINT	

Table 1: A brief summary of the features and performance of Radio Shack Level I BASIC, as available in the TRS-80.

Cassette Drive

The cassette drive interface can be used with any reasonably good audio cassette recorder, as outlined above. Data is recorded at a rate of about 250 bits per second. The recording method is designed to be reliable but does not employ any data redundancy or error correction capability. At first I had some trouble recording and playing back programs, but my results improved considerably when I set the tone control to zero. Like most cassette interface systems, the TRS-80 can get hung up searching for a signal on the tape that it never finds. A reset button near the expansion connector can be used to halt the cassette loading process, but afterwards memory may contain some "garbage" from the partially loaded program.

A problem frequently encountered when using audio cassette recorders with personal computers is that when a long program recorded on cassette is being read into memory, you don't know whether the computer is reading properly or has been unable to find the recorded program. The TRS-80 lets you know what's happening while a cassette is being read by flashing two asterisks on the screen when a program is found, and alternating between one and two asterisks while the program is being read. The TRS-80 also starts and stops the cassette drive motor automatically through the "remote" jack, but this means that you must remove the "remote" plug in order to manually rewind or fast forward the tape. This inconvenience is a necessary consequence of using a separate, standard audio cassette recorder without a manual motor control override implemented through operating system software.

Operating System

The TRS-80's operating system controls the cassette interface in response to commands and BASIC language statements. You simply type CSAVE to write the BASIC program currently in memory onto a cassette, and CLOAD to reload it later. The saved programs are not named and the CLOAD command will always load the next program it finds on the tape, but you can save several programs on the same cassette and find them later by writing down the settings of the tape index counter on a piece of paper. Also provided are PRINT# and INPUT# statements in BASIC which let you write and reread the values of program variables on cassette. Although Radio Shack plans to offer a second cassette interface, the syntax of the PRINT# and INPUT#

statements does not provide for references to different cassette units, so use of a second cassette drive will probably depend on support from "Level II" BASIC, which Radio Shack is said to be readying for future release.

Radio Shack Level I BASIC

Table 1 summarizes the features and performance of the Level I BASIC interpreter built into the TRS-80. The BASIC language features provided are somewhat limited, as might be expected in view of the fact that the BASIC interpreter and operating system fit in only 4 K bytes of read only memory. 26 possible variables can consist of one letter, but not a letter followed by a digit. Two string variables, A$ and B$, are provided and can be used in INPUT, PRINT and assignment statements, but string values cannot be compared. One singly dimensioned array variable, A(subscript), is provided, and all memory space remaining after the BASIC program and ordinary variables are allocated to this array. Each element of the array, a real number of up to six significant digits, takes four bytes of memory. Users requiring multiple arrays such as B(I) and C(J) must simulate by writing, for example, A(I) and A(10+J). Multiple dimensions may be simulated with expressions such as A(I+10*(J-1)), so having one array is obviously better than having none at all. Addition, subtraction, multiplication and division are provided but exponentiation is omitted, since this would require the EXP and LOG functions for exponentiation of real numbers.

Presumably Radio Shack's Level II BASIC, said to be due for release in early 1978 according to current expectations, will include a much more comprehensive set of BASIC language features. In the meantime, Level I BASIC can be used effectively for many computer games and for business applications with straightforward arithmetic calculations such as payroll (see below). But you can't plot a sine wave unless you write your own sine calculation subroutine.

Expansion

Radio Shack has announced plans to offer a variety of expansion options for the TRS-80, but very little detailed information on them is available at the time of this writing. Photo 5 shows the expansion port built into the TRS-80 which reaches the outside world through a small flip-up opening in the case. This 40 pin card edge connector no doubt includes the address and data bus, input, output, read, write, interrupt and interrupt acknowledge signals from the Z-80 microprocessor. A cable can be run

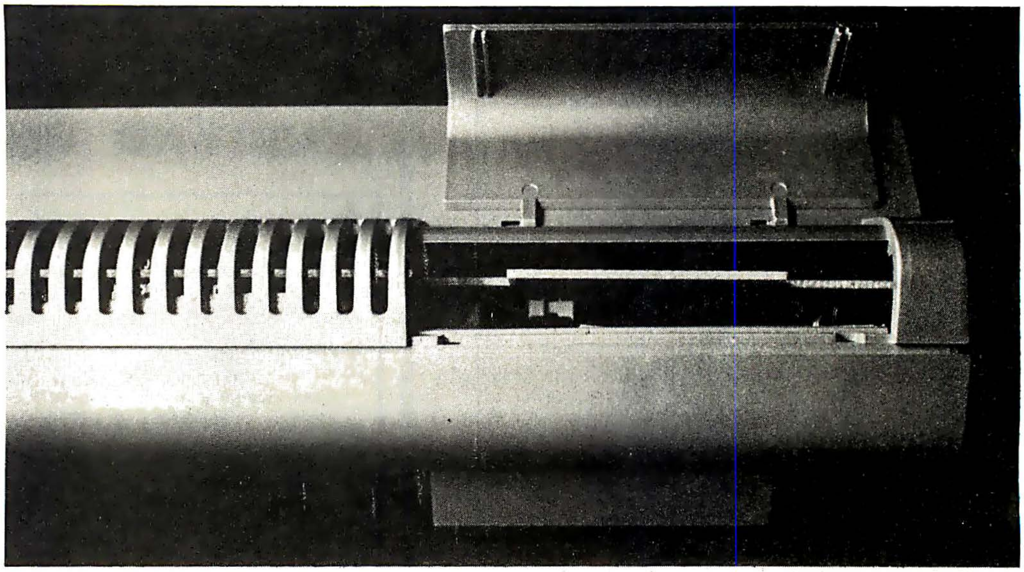


Photo 5: The TRS-80's expansion port, a 40 pin card edge connector which includes the address, data and control buses. This connector reaches the outside world through this flip-up opening on the back of the processor's case.

from this connector through various peripherals and a memory expansion unit. In all probability Radio Shack will use a daisy chaining arrangement which permits a single cable to be run from device to device. (Each device in the daisy chain would either accept an IO request or interrupt acknowledge signal, or pass the signal on to the next device.)

Peripherals for the TRS-80 currently foreseen by Radio Shack include a second audio cassette recorder interface, a printer reliable enough for business applications for about $1500, a smaller printer for less demanding individual applications for about $700, and a floppy disk drive also for about $700. Other planned options include a memory expansion unit and a modem to connect the TRS-80 to a timesharing or data communications system. Perhaps most significantly, however, Radio Shack has announced plans to offer an interface to the Altair (S-100) bus, which would provide access to the many memory and peripheral cards offered at competitive prices by other manufacturers.

Software

When the TRS-80 was announced, Radio Shack also introduced five small application software packages on cassette, all of which are designed to run on the basic TRS-80 with 4 K bytes of programmable memory. The first of these is a pair of game programs for blackjack and backgammon, which is included free with every TRS-80 computer. The display produced by the backgammon program is shown in photo 6. The program rolls the dice and maintains the board for two players, but does not provide for a 1 person game against the computer.

Other applications include a "kitchen" package which is said to provide menus, conversion tables, a directory and message center for $4.95; a "personal finance" package, apparently for checkbook balancing, for $14.95 including seven cassettes; an "education" package which provides drills in addition, subtraction and multiplication for $19.95 including three cassettes and a teacher's guide; and a "payroll" package for $19.95. The payroll package, which has been demonstrated to

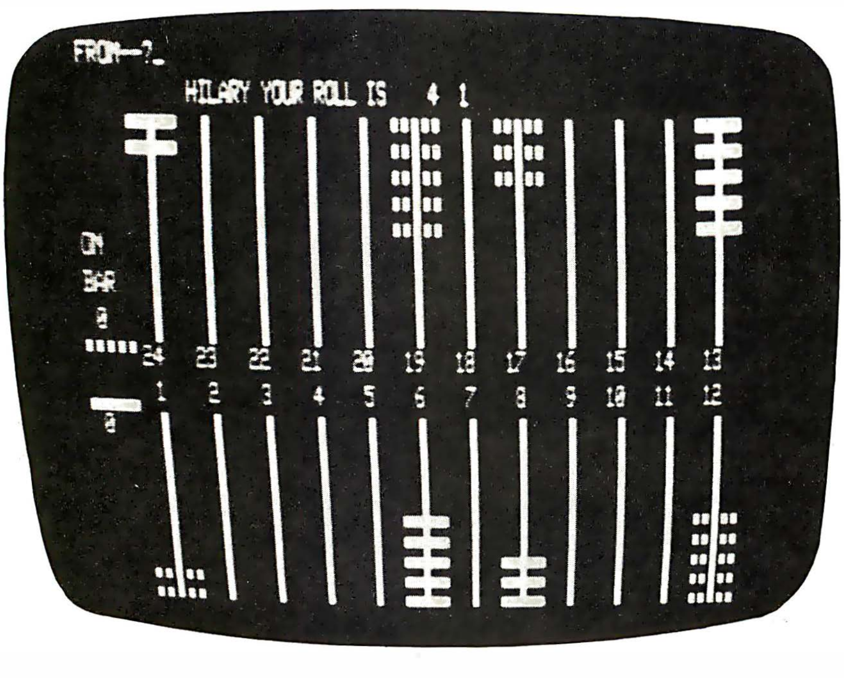


Photo 6: The display created by Radio Shack's backgammon game program, which is included free with every TRS-80 computer. This demonstration program acts as the dice roller and scorekeeper for the game, but makes no attempt to replace the two human players.

many interested businesspeople at trade shows, seems to require most of the 4 K memory for the program and handles just 15 employees on the basic TRS-80, but will handle 100 employees with 8 K of memory, and 300 employees with 16 K.

BASIC programs potentially useful with the TRS-80 can also be found in a number of books. Users will have to modify any such programs to fit the features of Radio Shack's Level I BASIC. In particular, variable names will have to be renamed and array references may have to be modified. And of course the total number of variable names used must be kept within Level I BASIC's limits. But this may still be easier than writing the programs from scratch.

Additional application packages are said to be planned for future release. The larger applications will probably require extended BASIC and a floppy disk. Also said to be in the works are an assembler, text editor, disk operating system and possibly compilers for other programming languages. It is not clear whether all this software will be developed in-house or will be obtained from outside sources. Some software undoubtedly will be developed by Tandy Advanced Products, another division of Tandy Corporation; Radio Shack also is thought to be negotiating with other software developers. In any case an enormous amount of effort will have to be invested in the development of this software.

Overall it seems that Radio Shack is aiming its application software and peripheral support primarily at the small business market, although applications for education, entertainment and home use are also clearly contemplated. Many related services, such as custom tailoring of application software and training of clerical staffs, will be required to meet the needs of small businesses, and perhaps knowledgeable hobbyists and small systems developers will be able to fill this need.

Availability and Delivery

When first announced, the TRS-80 was difficult to obtain like almost every personal computer. I ordered one on August 4 1977 and picked it up at my local Radio Shack store on October 11. The delay would have been even longer but for the special efforts of the store manager, Steve Lambert, who called me when another customer cancelled his order for a unit that had arrived at the store. In time, however, the TRS-80 should be among the most widely available personal computers, due to Radio Shack's widespread retail distribution and considerable manufacturing capacity.

At present you can order the TRS-80 at any Radio Shack store by placing a deposit of $100, which can be charged to a major bank credit card. The units generally are not stocked at the stores, although this is planned as the supply permits. When ordered the unit is delivered to the local store from Radio Shack headquarters in Fort Worth TX, where the TRS-80 is produced, with a planned order to delivery cycle of 30 days. Some stores have a demonstration unit on display. *[We recently saw one for example, at the Radio Shack store in Keene NH, not exactly America's biggest town ...* CH*]*

A major problem for Radio Shack is the education of store managers who will have to answer questions from customers on the TRS-80. The managers of the first 100 stores to receive the computer were flown to Fort Worth for a special training session, and this sort of training effort may well be necessary in the future. But with Radio Shack's profit incentives for store managers, it is a safe bet to predict that the TRS-80 will be effectively merchandised.

Warranty and Service

Service has always been a problem in the personal computer industry, and because of the complexity of the product and the possibility that the user will misinterpret some peculiar but correct action of the computer as a failure, service is likely to be a problem for Radio Shack as well. In anticipation of possible servicing problems, Radio Shack apparently has tried to make the TRS-80 as foolproof as possible. The inability of the user to drop into machine language is a good example of this approach. Similarly, the plastic case of the keyboard unit is sealed, and the warranty is voided if the user opens the case.

The user can return the unit to a local Radio Shack store, which will ship the unit to a service center and receive it and notify the user when the repairs are complete. Initially all servicing will be done in Fort Worth, but it is planned that regional service centers will handle the TRS-80 eventually. This servicing practice also applies to the removal and insertion of memory chips when the user wants to upgrade to a larger (8 K or 16 K) memory.

Conclusion

Like other "appliance" computers now on the market, the TRS-80 brings the personal computer a good deal closer to the average consumer. It is as easy to plug in and turn on as a TV set or a stereo system, and should be usable for a wide variety of interesting games, calculations and educa-

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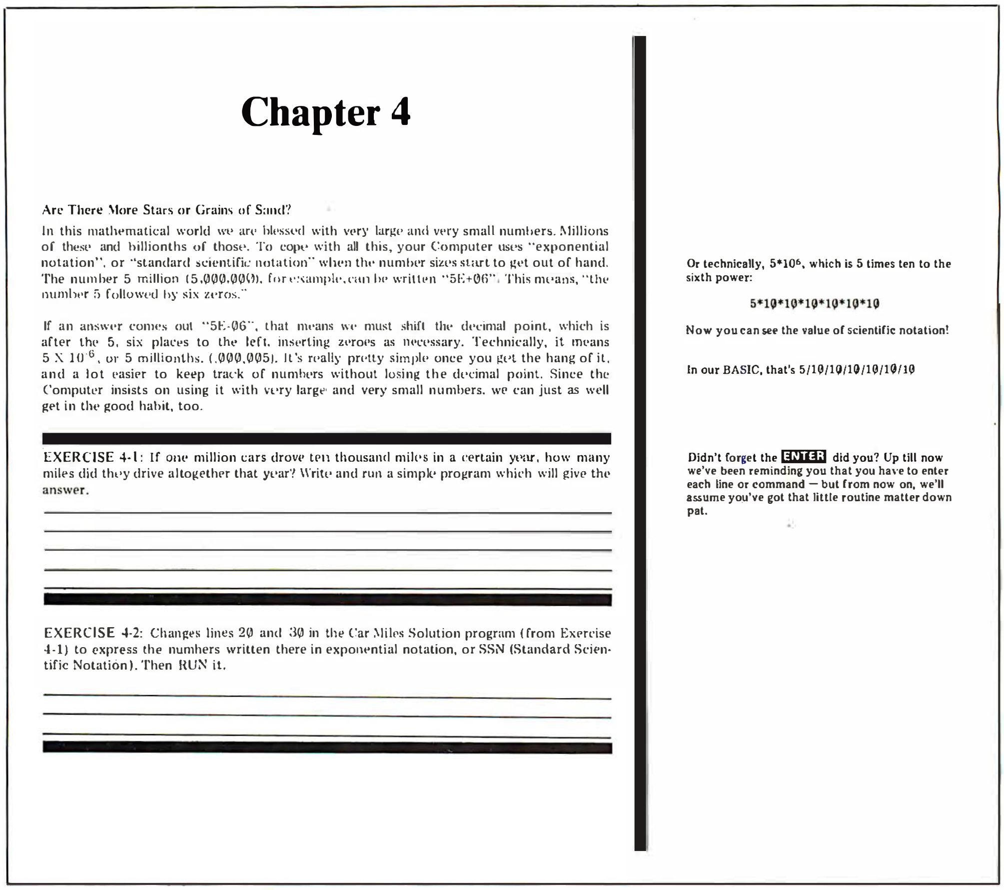
ADDRESS ______________________________

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PHONE ( ) ______________________________

tional drills. With a floppy disk and a printer it should be suitable for some business applications. Its BASIC language is somewhat limited at present, but this should be remedied when Radio Shack Level II BASIC is finally available.

The TRS-80 is not the only alternative for the aspiring personal computer user, but it is a strong contender. If you are thinking about a purchase, compare its features against other offerings along all dimensions, including capabilities, software, warranty and service, and expansion possibilities. Talk to owners of the TRS-80 and other personal computers, and think about what you intend to do with your own computer. I hope that this review article will help you in your evaluation.■



Chapter 4

Are There More Stars or Grains of Sand?

In this mathematical world we are blessed with very large and very small numbers. Millions of these and billionths of those. To cope with all this, your Computer uses "exponential notation", or "standard scientific notation" when the number sizes start to get out of hand. The number 5 million (5,ØØØ,ØØØ), for example, can be written "5E+Ø6". This means, "the number 5 followed by six zeros."

If an answer comes out "5E-Ø6", that means we must shift the decimal point, which is after the 5, six places to the left, inserting zeroes as necessary. Technically, it means 5×10^{-6}, or 5 millionths. (.ØØØ,ØØ5). It's really pretty simple once you get the hang of it, and a lot easier to keep track of numbers without losing the decimal point. Since the Computer insists on using it with very large and very small numbers, we can just as well get in the good habit, too.

Or technically, $5*10^6$, which is 5 times ten to the sixth power:

5*1Ø*1Ø*1Ø*1Ø*1Ø*1Ø

Now you can see the value of scientific notation!

In our BASIC, that's 5/1Ø/1Ø/1Ø/1Ø/1Ø/1Ø

EXERCISE 4-1: If one million cars drove ten thousand miles in a certain year, how many miles did they drive altogether that year? Write and run a simple program which will give the answer.

Didn't forget the ENTER did you? Up till now we've been reminding you that you have to enter each line or command — but from now on, we'll assume you've got that little routine matter down pat.

EXERCISE 4-2: Changes lines 2Ø and 3Ø in the Car Miles Solution program (from Exercise 4-1) to express the numbers written there in exponential notation, or SSN (Standard Scientific Notation). Then RUN it.

A Last Minute Note

As this article was being prepared, we received a copy of the Radio Shack User's Manual For Level 1. *The manual is 232 pages long with a GBC binding and is written by Dr David A Lien of San Diego CA. A note from the author states its purpose as a tutorial:*

> . . . This book is written specifically for people who don't know anything about computers, and who don't want to be dazzled by fancy footwork from someone who does. It is written to teach you how to use your Radio Shack TRS-80 and start you on a fast track to becoming a competent programmer. To that end, every fair and unfair, conventional and unconventional, flamboyant and ridiculous technique I could think of was used. I want you to have fun with your computer! I don't want you to be afraid of it, because there is nothing to fear. . . .

The basic layout of the manual is illustrated by the reproduction of page 23 above. It features a wide page format with details on the lefthand side of the page, and points of emphasis (sometimes including cartoons) represented as screened boxes of text on the righthand side of each page. On a basis of first impressions, Dr Lien has completed an excellent tutorial presentation to accompany the TRS-80 computer. . .CH

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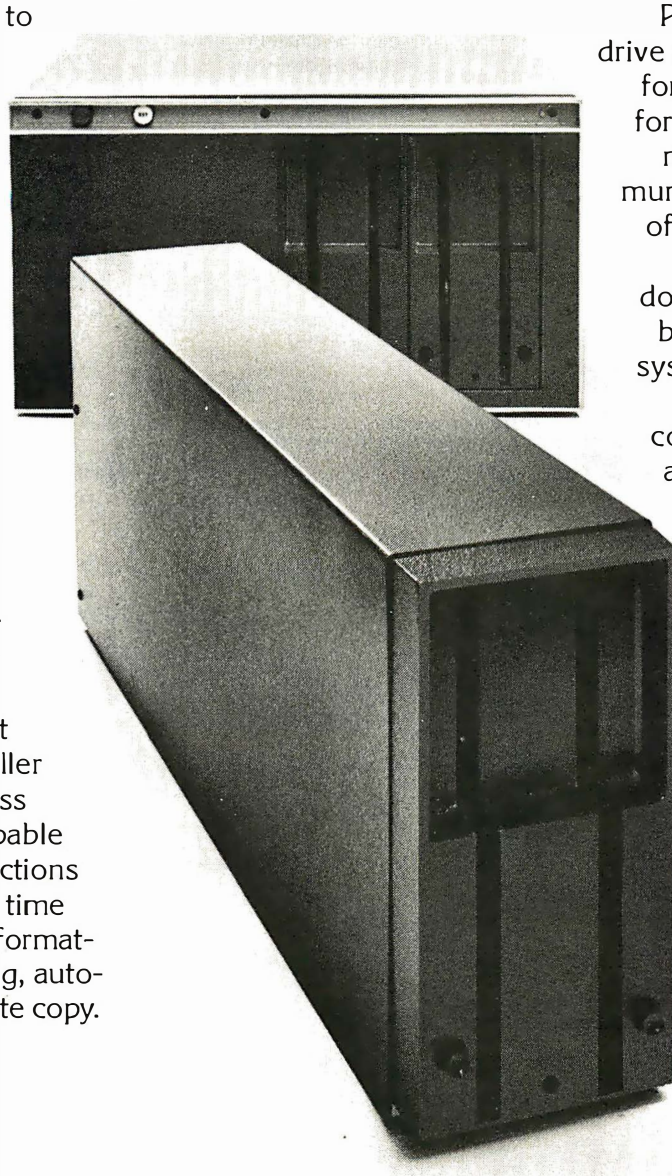
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BYTE's Bugs

A Bug in the Clockwork

The collection of articles dealing with real time clocks published in the November 1977 BYTE was timely and interesting. I found the approach of M F Smith (page 50) appealing in its simplicity. However there is an error in the listing given for the interrupt handling routine. The offset between the time values and the overflow values is stated incorrectly. Line 29 of the listing should be:

```
00029 A068 A1 08   CMP A 8,X   CARRY?
```

since the correct index register offset is 8, not 7 as given. With this correction, the routine works well.

Your decision to publish a group of articles dealing with a single subject in a particular issue of BYTE is commendable, and I hope this practice will be continued. I certainly find it more stimulating to encounter a collection of related articles (even if they deal with a subject in which I am not particularly interested) than to read just a single isolated article.

B W Bangerter, Research Associate
Dept of Chemistry
Harvard University
12 Oxford St
Cambridge MA 02138

Oops! You're right. Listing 1 is shown with the change in line 29 here:

```
PAGE  001   RAMTIME

00001                               NAM    RAMTIME
00002  A04A                         ORG    $A04A
00003  A04A 00                      FCB    0          DUMMY LOCATION
00004  A04B 00           DAY        FCB    0          TIME IN PACKED BCD FORMAT
00005  A04C 00           HOUR       FCB    0
00006  A04D 00           MIN        FCB    0
00007  A04E 00           SEC        FCB    0
00008  A04F 00           SEC1       FCB    0
00009  A050 00                      FCB    0          DUMMY LOCATION
00010  A051 00           WATCH      FCB    0          BINARY 'STOPWATCH' LOCATION
00011                    *
00012  A052 99                      FCB    $99,$99,$24,$60,$60
       A053 99
       A054 24
       A055 60
       A056 60
00013                    *
00014  A057 10           RATE       FCB    $10        *CLOCK RATE
00015                    *
00016                    *FOR DIFFERENT CLOCK RATES, CHANGE RATE
00017                    *E.G., FOR 60 HZ CLOCK CHANGE TO $60
00018                    *1-99 HZ ALLOWABLE CLOCK RATES
00019                    *
00020  A058 CE  A051     TIME       LDX    #WATCH     TIME PROGRAM BEGINS HERE
00021  A05B 6C  00                  INC    0,X        INCREMENT THE STOPWATCH
00022  A05D 09                      DEX               DECREMENT TIME ADDRESSES
00023  A05E 6F  00       DINC       CLR    0,X        CLEAR ON CARRY
00024  A060 09                      DEX               NEXT ADDRESS
00025  A061 86  01                  LDA A  #1         DECIMAL INCREMENTATION/CARRY
00026  A063 AB  00                  ADD A  0,X
00027  A065 19                      DAA               HALF CARRY
00028  A066 A7  00                  STA A  0,X        COMPLETE DECIMAL INC
00029  A068 A1  08                  CMP A  8,X        CARRY?
00030  A06A 27  F2                  BEQ    DINC       YES, CARRY
00031                    *
00032                    ***SCHEDULER(S) INSERTED HERE***
00033                    *
00034  A06C 3B                      RTI               RETURN TO PROGRAM
00035                    *
00036                               END

TOTAL ERRORS 00000
```

■

A Bug in the EROM

In table 1 of last month's Ciarcia's Circuit Cellar, "Program Your Next EROM in BASIC," (BYTE, March 1978, page 88), IC4 was incorrectly identified as a 7407; it should have been labeled as 7406. Note 3 on the same page should read: "Note that IC4 is a 7406. A 7416 should not be used." Figure 1 correctly shows IC4 as a 7406 hex inverter gate. Thanks go to Tim Walters and the other readers who spotted this error.■

Rated G

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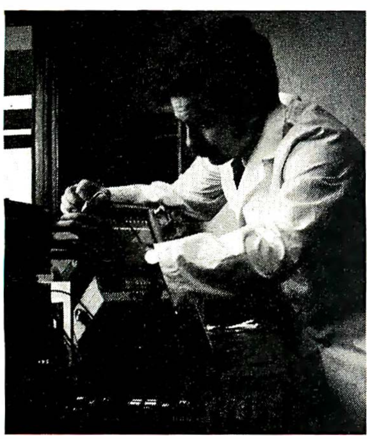
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One Step at a Time

I was glad to see S P Smith's article on simulation in November 1977 BYTE, page 18. That happens to be my specialty and an area that I feel has been neglected in personal computing. I'm afraid Steve erred in his discussion of the numerical integration, though. Over a given step, the average speed is equal to half the sum of the initial and final speeds. In the example, the average speed is ½(100 + 99.16) = 99.58 meters per second. Thus the LEM will fall 9.958 meters in 0.1 seconds, and the new position will be 10000. −9.958 = 9990.042. Admittedly, the difference is small and if we take a small enough step size, it becomes negligible. However, steps of integration cost computer time, and if we're going to have a real time simulation, we need to get the most accurate integration for a given step size that we can. Just for the record, there are many much more accurate algorithms for numerical integration. At work we use a second-order method for all real time work. It's hardly more complicated than Steve's (requiring saving only one back point) but about two orders of magnitude more accurate.

Dr Jack W Crenshaw
2114 Cecille Dr SW
Huntsville AL 35803■

Improving an Improvement

In the November 1977 BYTE an article called "An Improved Lunar Lander Algorithm" by Stephen P Smith (page 18) has one small bug in it. If the user is using an interactive terminal to input the values for vertical and horizontal thrust, a situation can arise where the LEM can gain mass. This is how: if the value for USR(1.) is zero, simulating free fall, and the value for USR (2.) is negative; then the equation M=M−(A+B)*I*D results in M=M−(0+(−B))*I*D=M+B*I*D. In order to avoid this situation, we suggest that your interactive users change the mass equation to M=M−(A+ABS(B))*I*D. This new equation also prevents the case where the mass remains the same after a burn.

R Jovonovich
G Leenarmen
Sperry Univac
2276 Highcrest Dr
Roseville NM 55113■

Numb NIM

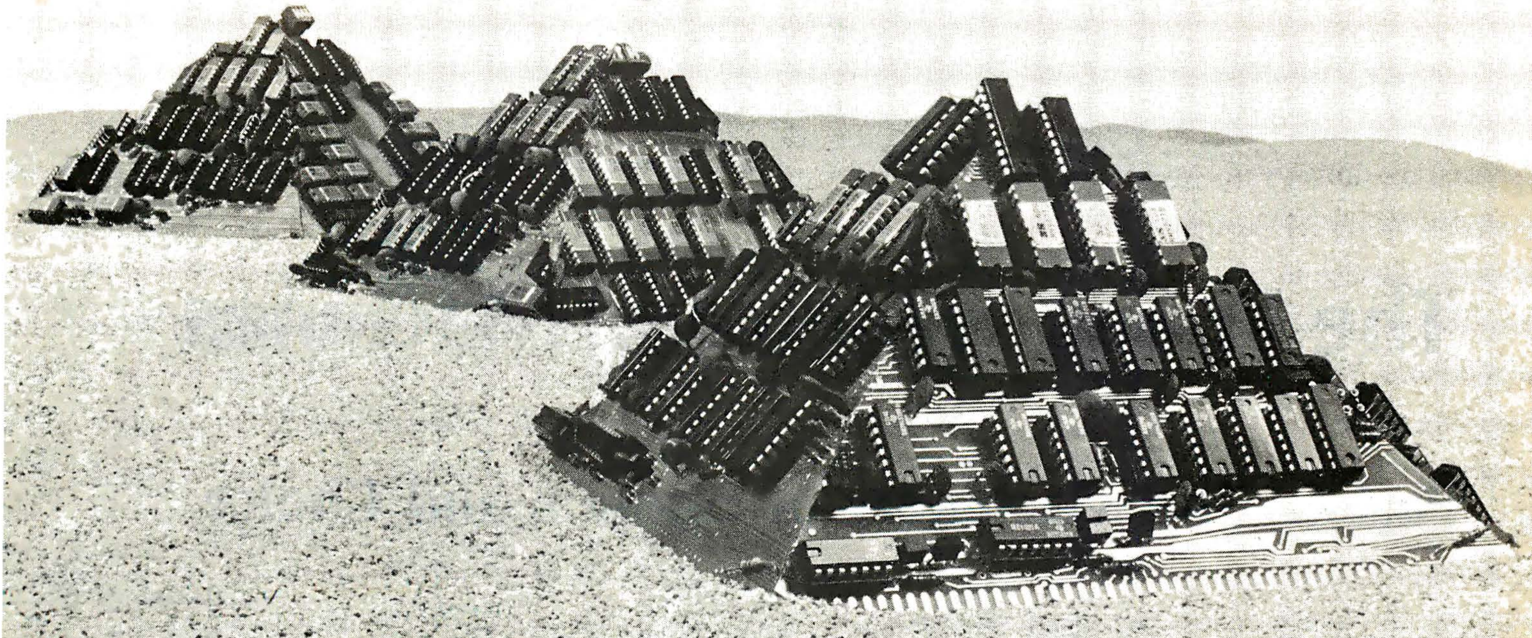
Re your November 1977 article, page 172, entitled "NIMBLE: The Ultimate NIM?": on page 177, in the last paragraph there appears to be an obvious mistake. Comparing the program logic with the statements in this last paragraph, there is a direct contradiction. I believe the second sentence of the paragraph should read "If it *is* equal to 0 there is no optimal move. . ." Also the third sentence should read "If P *is not* equal *to* 0. . ." I believe this was just an inadvertent juxtaposition of the two basic statements by the author.

Fletcher Thane Carson
1778 Ala Moana Blvd #1004
Honolulu HI 96815■

Checking Checks

On page 129 of January 1978 BYTE there are two errors in the BASIC listing of the checkbook balance report program. Line 1130 of the listing should be setting the FALSE flag to 0 instead of 1. The other problem is the transaction loop at lines 610 to 630. This loop will not be exited until the ENDTR flag is set true. This state does not occur unless an end of file is encountered. Line 985 should read IF OLDDAY #DAY THEN LET ENDTR = TRUE. This will succeed in terminating the loop.

Thanks to both Don Walker and Jean-Yves Bernier for detecting these bugs.■



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The Brains of Men and Machines

Part 4: The Machinery of Emotion and Choice

Ernest W Kent, Associate Professor
Dept of Psychology
The University of Illinois at Chicago Circle
Chicago IL 60680

In the preceding articles of this series (BYTE January, February and March 1978), we have examined the general organization of the brain, the nature of its components, the methods by which its general output strategies are converted into actual motions, and the ways in which its inputs are recoded as high level perceptual constructs. In this final article, we shall examine the central process in which the inputs are employed in the generation of output decisions.

There are two basic aspects to this process. One is the cognitive or rational aspect of brain operation, analogous to the ordinary logical processes of the computer in function, if not in detailed operation. The other aspect is the motivational component, which defines the goals to be achieved. This term covers concepts such as emotions, drives, desires and the like. In most standard computer situations, these goals are analogous to the purpose of a program, which is in turn implicit in its operation. They are rarely defined in terms of computer hardware. This means that one of the major differences between brains and present day computers is that brains determine their own behavioral directions or objectives, whether by prewired reflex or by learned processes, whereas computers are built to passively accept whatever purpose is inherent in the current program. As we shall see in the following discussion, there is no fundamental reason why a robot brain could not be built to operate somewhat like a natural brain in this regard.

Taking the problem of motivation first, let us look at some of the terms that have been used to describe motivations, what motivations do for an organism, and what kinds of them there are. If we start with the notion that they are that general class of cerebral events which determines the objectives of behavior, a wide variety of things immediately come to mind; almost everything we do has some objective or purpose. There are however certain broad categories into which these many objectives can be grouped, and these categories can be further subdivided as well. This can be done in such a way that there is a match between the various categories, and some of the functional systems of the brain.

First of all, we might divide our motivations into the two categories of "seeking pleasure" and "avoiding pain." I know you will immediately think of many situations in which our behavior seems to have as its object things that may bring us pain, out of a sense of duty or altruism for example; but these are probably best considered as instances where the avoidance of duty or the failure to behave in a commendable manner would bring the greater displeasure. These types of motivation can then be seen as the pursuit of less direct goals such as self-esteem, and the avoidance of pains such as guilt, instead of the more obvious direct results of such behaviors. (This type of motivation involves learned processes, and we shall concern ourselves here with simpler types for purposes of illustrating the basic principles.) This division into pleasure seeking and pain avoiding motivational states reflects one of the brain's fundamental operating decisions. Brains evolved from the

Note: *The terminology utilized in this article was covered in detail in the first part of this 4 part series, which appeared on page 11, January 1978 BYTE.*

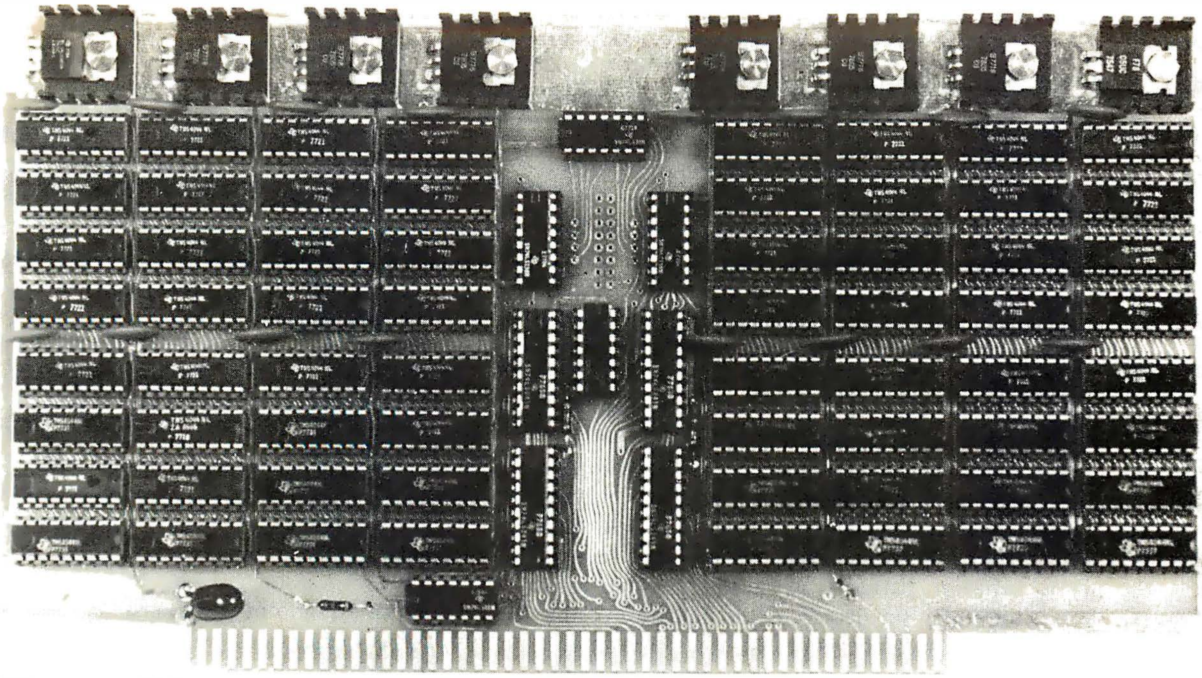
first as control systems for organisms with clearly defined biological needs to seek some types of things and to avoid others. All organisms with brains, however simple, seek to eat and to avoid being eaten.

To this end, the brain has evolved two major functional systems, operating in synergy, which transform information on bodily needs and environmental events into levels of activation and choices of behavioral options throughout the rest of the brain. It is an oversimplification to describe these strictly as "pleasure and pain systems," but such a description has considerable validity. In our laboratories at the University of Illinois at Chicago Circle, we are devoting most of our attention to studying the operation of these systems, in particular their goal directing functions, in the belief that this will reveal some of the most basic foundations of behavior, however far removed the behavior may be from the simple purposes around which these systems were initially developed. These goal directing systems are located largely in the regions of the brain called limbic system, hypothalamus and mesencephalon. Most of their detailed connections are of only marginal interest here, since a robot system will probably have very different motivational requirements than a biological organism. We shall concentrate instead on their functional roles and the details of their interactions with the other brain systems.

One of the further subdivisions of the motivational complement of all organisms is a rather loosely defined set of operating states called "drives." In general, this refers to states which we recognize by such names as hunger, thirst, sex drive, suffocation, pain (in the more specific sense of a particular bodily sensation) and a host of similar terms. These refer in most instances to need states of the organism, and are the most obvious sorts of goals which might direct and energize behavior in the rest of the brain. Two general classes of drives have emerged which are differentiated by their modes of operation, and which have a general applicability to robot systems as well. These classes are the "homeostatic" and "nonhomeostatic" systems. Homeostatic systems, of which hunger is the customary example, operate in such a way as to maintain a proper level of some important quantity or state in the organism. In the case of hunger, there is a system which monitors the level of energy reserves in the body's chemistry and translates this into altered states of activity in the brain when these levels fall critically low. The activation of this system changes the operational state of a variety of other systems and thereby causes the organism to engage in behaviors which result in the acquisition and ingestion of food. Stimuli resulting from food intake in turn cancel the inputs to the hunger system, and the organism's behavior returns to other goals. The whole process could be likened to the operation of a thermostat in maintaining temperature. In its overall operation, it is basically a feedback mechanism.

Nonhomeostatic mechanisms do not operate under the control of such cyclically recurring needs, and do not function to maintain a particular control level of a quantity or process. In other ways, however, they are similar. An example is the response to pain. Here the motivational system operates only when, and if, certain external stimuli happen to occur. If the organism is unfortunate enough to encounter a painful set of circumstances, such as blundering into a patch of thorn bushes, systems which detect pain immediately assign the highest priority to behaviors which will remove the organism from the painful situation. This motivational state will persist until the immediate environmental stimuli are escaped or eliminated. Both types of drive mechanisms serve to direct behavior towards situations which will meet the organism's immediate needs.

It is obvious that efficient operation requires more than simply being programmed to consume food if we blunder into it when hungry. The organism must also respond, when hungry, to stimuli which signal the availability or direction and location of the food. Certainly when hungry we find the smell of food or the sight of food or even the sight of the restaurant pleasurable. In fact, however, even the taste of food is not the real object of the hunger drive. The joy produced by the taste of food when hungry serves as a stimulus to continue eating, but the object of the hunger drive state is repletion of energy levels, not the joy of eating. Nonetheless, the pleasure associated with stimuli which signal food, or the fear associated with stimuli that signal pain, serve to both energize and direct our behavior. Since we have assigned this function to motivational states, we must consider these emotions to be part of motivation too. Emotions of course are recognized as powerful "motivations" in our daily experience, and they are intimately related to drive states in governing our behavior. It is important to distinguish between the operation of the brain's emotional systems with their effects on behavior, and the subjective experiences we usually call "emotion" which are, or are dependent



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upon, the operation of these systems. Let us first consider the relationship of emotions to drive states and brain operation.

In general, the brain's emotional motivational system deals with stimuli which *anticipate* objectives of drive states. That is, there are systems in the brain which respond to stimuli which normally occur prior to contact with the actual goal object. These systems are among those activated by the drive state operating at the time, so that a whole host of stimuli associated with the object of the current drive state are selected for detection. When, in the case of pleasure seeking systems, these stimuli are detected, behavior patterns are initiated which lead the organism nearer to the objective of the drive state. The contrary holds true in the case of the pain avoidance process. Stimuli which signal a situation which can lead to painful stimuli, but are not in themselves painful, still lead to energizing and directing appropriate behavior. The sight of a long drop, the edge of a tall building's roof, for example, is not painful, but it signals potential pain and it is a stimulus which can activate an emotional system (fear) which directs us away from the dangerous situation.

In the case of homeostatic drive systems, the ability of the goal-relevant stimuli to activate the emotional system is dependent on the operation of the drive state. The smell of food is not pleasurable when you are already stuffed. In the case of the non-homeostatic drives, detection of the goal-relevant stimuli usually leads to operation of the motivational system as readily as the drive stimulus itself. Thus, it is not required that we first feel pain in order for us to feel fear of the pain related situation and act on such fear. The actual goal related stimuli which serve to operate the emotional systems may be simple and "hard wired," or they may be complex and effective only when learning processes associate them with the object of the drive state. Through experience we can thus expand the range of stimuli which we can use to energize motivational systems. This serves to make our goal seeking behavior much more efficient.

When operating, the motivational system not only energizes and directs behavior, but also appears in our subjective experience as "emotions" or "desires." The operation of the hunger drive state mechanism is perceived subjectively as the feeling of "being hungry." The sight of food in these circumstances activates emotional systems whose operation is subjectively experienced as the "feeling of joy." The activation of emotion systems which detect danger signaling stimuli is experienced as the feeling of "being afraid." It should be noted that making this distinction eliminates a problem posed by the old question of whether or not a machine could have emotions. If by "having emotions," you mean having a mechanism operating which detects certain types of situations and calls for certain categories of response, the answer is yes, clearly, and it could function just as usefully and efficiently as yours. If on the other hand, you mean can a machine have a *subjective* experience of fear when this mechanism is operating, the question is probably unanswerable.

Strictly speaking, we cannot even say whether or not another person has subjective emotional experiences; we can only know that he engages in emotional behaviors in appropriate circumstances, including behaviors such as saying, "I am afraid." With respect to the construction of a robot device, however, the question of subjective experience is not the essential point. What is important is to recognize that the brain processes which give rise to subjective emotional experiences in us do not have this experience as their purpose. Their purpose is to provide certain useful types of information processing relevant to increasing the power and efficiency of our behavioral responses to our environment. These processes remain as essential to efficient action in a robot brain as they are in an organic brain, irrespective of whether or not they are associated with subjective experiences.

Heuristics and Control

Let us turn now to the actual mechanisms of operation of the motivational system. To a limited extent, motivation in the brain is analogous to an interrupt system in a computer, and it has a priority structure too. Motivational systems of the brain are more complex than an interrupt structure, however, because they do not simply detect specified conditions and turn control over to specific programs of action. Instead, they enable classes of activity and define relevant goal stimuli. While the actual activity undertaken within the operation of a particular motivational state may vary widely, it is only the desired end result which is determined. The behavior that leads you to the food when hungry may be anything from reaching into the refrigerator to looking for a job, or even going hunting. This is a heuristic rather than an algorithmic process, and that is one of the most important distinctions between a brain and ordinary computer operation. In an algorithmic process, the goal is assumed, and

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a sequence of steps is executed which, if executed correctly, is known to lead to the goal.

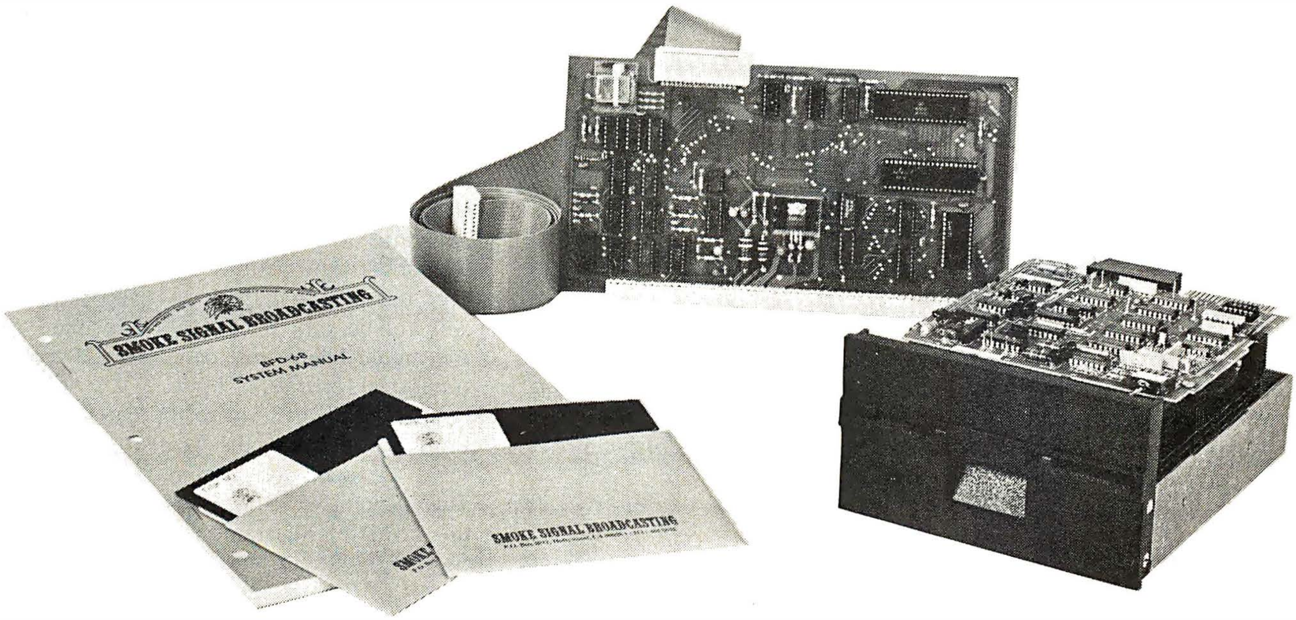
In a heuristic process, potential results of different paths of action are compared with the goal, and those that seem to lead to states closer to the goal state are executed. The process is then continued, perhaps even with backtracking when it is discovered that a promising course led to a blind alley. This heuristic approach has been implemented occasionally in software; the chess playing programs are good examples; and simple heuristic systems were implemented in hardware even in the earliest robot systems. In one of these systems, for example, the goal was recharging the battery. The "drive state" was initiated by a relay that opened when the voltage fell below a prescribed level, and its action was to place the forward motor drive under control of a directional photocell. The goal related stimulus was a light mounted over the battery charger. When the light was in line with the device's forward direction of motion, the photocell was activated (emotional response) and the machine rolled forward (motivated behavior). When the device was not lined up, it turned at random but did not move forward. It was never guaranteed that the sequence of behavior was correct (consider the consequences of a mirror for example), but within the behavioral potential of the device, it was a best guess.

This type of heuristic system is very similar to that employed by simple brains, and by the simplest modes of operation of motivational systems in advanced brains. To begin with, recall our earlier discussion of the motor output system. We left off at the point where the highest levels of the system received two types of input, one from the cortex and thalamus carrying information on "suggested" behavior patterns encoded in spatial digital form, and another carrying information on the desirability of the current stimulus situation, encoded in temporal analog format. The result of the interaction of these two inputs in the motor system was that the "suggestion" made by the cortical-thalamic inputs was interpreted into continued motor output patterns by the basal ganglia only so long as a continuing "enabling" action was maintained on the "reward detector" input. This will result in a system which exhibits the sort of goal directed behavior shown by the photocell guided robot mentioned above, provided that the reward detector is activated by goal-relevant stimuli. Thus, when the behavior pattern specified by the cortex is translated into temporal motor output patterns by the basal ganglia and cerebellar systems, the behavior only continues if its consequences produce an input from the "reward detector" system which sustains the current behavior. Otherwise, it dies out and other behaviors take precedence. Just as in the simple robot system, this sort of action will often lead to the goal, even if the various possible behaviors are generated at random. It will not however be very efficient.

This defines one aspect of the operation of the motivational system in a heuristic device: it must gate the reward detector to respond to the class of stimuli which is relevant to the goals of the drive state in question. If we wanted to give the simple robot two motivational options, for example, we would need a system to switch between the photocell and something else, say a microphone, to activate the forward locomotion circuit. Then we could use a speaker to define the location of some other goal, and the goal which was approached would depend on whether the locomotion circuit was driven by the photocell or the microphone. The major difference in the brain is that whole categories of complex stimuli are enabled into the reward circuitry by the drive state, rather than just a single simple stimulus. Moreover, these range from the most straightforward stimuli, which are probably hard wired into the motivational circuit from birth (the taste of food for example), to the most complex stimuli which are clearly learned in later life (a sign offering food for sale). Like most systems of the brain, this one has a hierarchical representation at various levels, and more complex stimuli are dealt with in more advanced structures, while simpler ones are handled at anatomically (and evolutionarily) lower levels.

It is easy to see how a system which detects a need state and initiates a drive operation might gate some simple and specific stimuli into the reward system, but it is not so clear how complex learned stimuli are to be dealt with by a system that must specify classes of events. Research has revealed that the structures of the limbic system are centrally important to our emotional functions as well as to our reward system, and these regions seem to be necessary for activating the reward system when the goal-relevant stimuli are complex and learned. These limbic system structures are also in close connection with the regions of the hypothalamus and other lower centers which function in the detection of need states. Further, limbic system structures receive a wealth of projections from cortical areas which are involved with the higher levels of perceptual feature extraction of the

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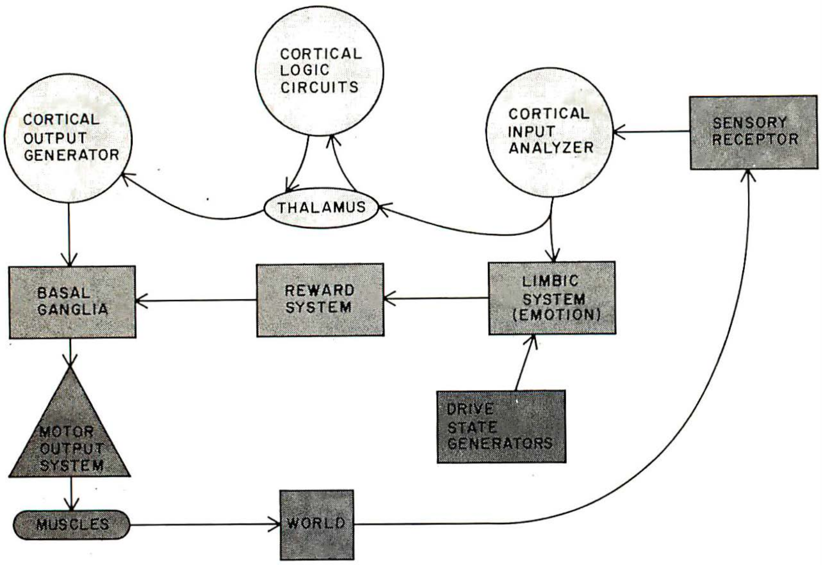


Figure 1: General paths of information flow in goal directed behavior. Information from the senses is analyzed both for generation of new action patterns, and for increase/decrease decisions about current actions. The latter decision is based on the rate of increase of satisfactory stimuli of types relevant to the goal determined by the drive state generators.

sort described in the last article. If you recall this process, you will remember that the essential ingredient is the definition of the feature by selective convergence of a variety of inputs from lower level feature extractors. There is no essential reason why the "feature" in this process must be related to a perceptual construct of the type we were dealing with then. In other words, although the process described was presented in terms of the elements of visual object recognition, it would be equally applicable to what might be termed "emotional perception." That is, the emotional relevance of a visual stimulus could be considered as much of a feature to be extracted as its intellectual identification.

We shall say more of this higher level extraction process, but for now just consider how an emotional feature extractor might be wired up. Let us say that as a start we already have a small number of lines encoding the identification of some object in the visual field regardless of location, etc. Now suppose that the output of such elements converges, among other places, on elements of the limbic system, and that the convergence is selected so that the "feature" which is extracted by the target neuron in the limbic system is "relevance" to some drive state. (Exactly how these connections are determined is not important; it might be hard wired or established through a later process of learning.) We would then have a group of limbic system neurons which would respond to many stimuli relevant to a particular drive state. Such limbic system elements, each driven by a multitude of perceptual objects, would easily be enabled by inputs from the system responsible for gating classes of drive-relevant stimuli onto the reward bus. The essential element here is to see that the problem of decoding stimuli for emotional content is the same in terms of information processing as the problem of decoding them for logical purposes, and that much of the same circuitry can serve both functions, since it is only after the level of object identification that the convergence patterns are different.

Exactly how this emotional perceptual apparatus is connected in detail is not yet well-understood, but it appears that whatever the precise nature of its operation, it will not be very different in principle from the model I have just described. Its general functional operation in terms of behavior is established. In terms of potential applications to robotics, the present model will serve to adequately summarize these facts. The general scheme is presented in figure 1. In this diagram we see that the data flow from the receptors follows two main routes. After preliminary analysis in the sensory cortex, the data is available both to the limbic system for motivation-relevant feature extraction processes, and to the other areas of the cortex for logical analysis. The information which is processed in the limbic system can activate the reward mechanism if (1) the information decodes to features relevant to a drive state and (2) the limbic system elements which decode it are gated onto the reward system bus by activity of the appropriate drive state mechanism. When these conditions are met, the behavioral strategies developed by logical analysis of the sensory data can continue to be translated into motor patterns by the basal ganglia and other portions of the output system.

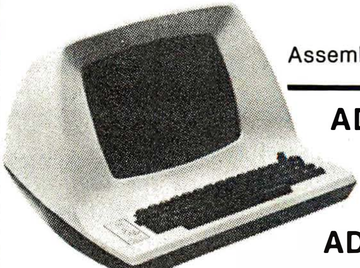
There seems to be a large component of the reward value of positive stimuli which is due to the rate of increase, or derivative, of the decoded stimulus rather than its absolute value. The situation with nonhomeostatic motivations and pain-escape behaviors involves the same machinery, with some differences. In the case of escape and avoidance behaviors, it is of course the *reduction* of activation of certain stimulus elements which serves to activate the reward mechanism, presumably through release of inhibitory elements. In the case of nonhomeostatic behavior, the situation is reminiscent of the difference between maskable and nonmaskable interrupts. Stimuli relevant to nonhomeostatic drive states are

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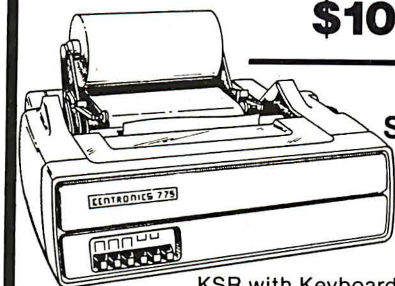
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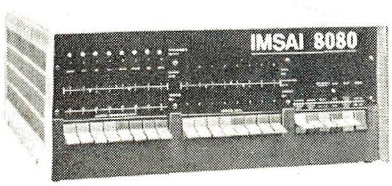


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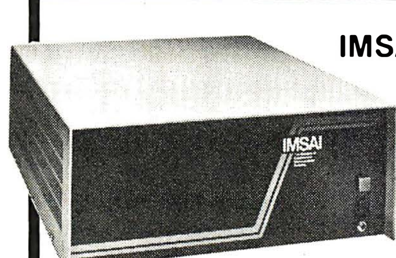
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"nonmaskable" in the sense that the drive state does not have to be activated in order for them to have an effect. What seems to occur here is that the decoding of these stimuli serves to initiate the action of the drive state, thus energizing the organism's behavior, and the subsequent reduction of these stimuli by successful behavior serves to activate the reward mechanism and direct the behavior.

What we have described accounts for the most basic function of motivational systems, their elementary goal directing functions. Several other important functions remain to be mentioned; among these are: the energizing or activating properties, the cue or stimulus properties, and the property of reinforcement of learning. To take them in order, it is clear from the above discussion that there will be an increase in general activity level resulting from an encounter with stimuli associated with a goal object, for example, directed locomotion towards the goal which arises when the motor system is gated open. This is referred to in psychological jargon as "incentive activation." In addition, there is an increased activity level resulting from the operation of a drive state generator in the absence of any relevant stimuli. This appears to be a general increase in levels of behavioral motor output, irrespective of any specific relation to the drive state. Many different kinds of drives, for example, will produce increased measures of general activity in devices such as running wheels, jiggle cages and the like which measure such activity. The phenomenon is called "nonspecific" activation, and its utility to the organism seems apparent. If a drive state develops, the organism has a statistically greater chance of encountering relevant stimuli if it moves around in the environment, even when such movement is random and undirected (notice how people tend to pace when highly motivated). The same argument would of course apply to a robot system.

The "cue" property of motivational states refers to the fact that the operation of motivational mechanisms generally gives rise to internal sensations which may themselves be considered as sensory stimuli, capable of entering into the information base on which the logical functions operate to produce behavioral strategies. Thus, the organism "knows" when it is hungry, and this data can itself be employed in conjunction with information from memory and sensory input to generate behaviors for trial. These are much more likely to lead to successful results than random behaviors. This makes the system much more efficient than one which, like the simple robot, simply gates the continuation of successful behaviors. This is because successful behaviors (those that lead to encounters with goal relevant stimuli) are much more likely to occur. For example, if the information about operation of the hunger drive is used in conjunction with information about current location to form a "memory address," any information about known encounters with food sources in the vicinity can be accessed and used to generate behaviors with greater heuristic value than random exploration.

Finally, we must consider the role of the motivational systems in the reinforcement of learning. You will recall that in the first article of this series, I mentioned two kinds of learning process; one was Pavlovian conditioning which depended only on the temporal contiguity of a stimulus which was initially neutral, and a stimulus which naturally evoked some behavior. We saw that repetitions of this pairing led to the ability of the initially neutral preceding stimulus to evoke the behavior normally evoked by the second stimulus. It appears that this type of conditioning may be a fundamental property of neurons. A distinguishing feature of this type of learning is that only the pairing is important, not the consequences. The second type, however, called "operant conditioning," is entirely dependent on the consequences. Behaviors which the organism emits and which are followed by activation of the reward system tend to occur more frequently. Those which fail to generate activation of the reward system tend to occur less frequently in the future. This type of learning is of course enormously useful in improving the range and efficiency of the organism's behavioral repertoire, since it can be used to modify existing behavioral chains by the insertion or deletion of elements, or to build up entirely new behavioral sequences out of accidental successes. This occurs even if the reward system is driven directly by electrical brain stimulation, thus bypassing all the circuitry which normally decodes the environmental and drive state stimuli. It appears that the reward system must be involved in this process, and there is mounting evidence that the basal ganglia participate in important ways as well. It is possible, although not definitely established, that a process of classical conditioning operating between the inputs to the basal ganglia could account for the phenomenon of operant conditioning. This theoretical model will be presented here as the easiest approach to model in a robot brain.

From what we have said already, it is clear that a successful behavior involves two

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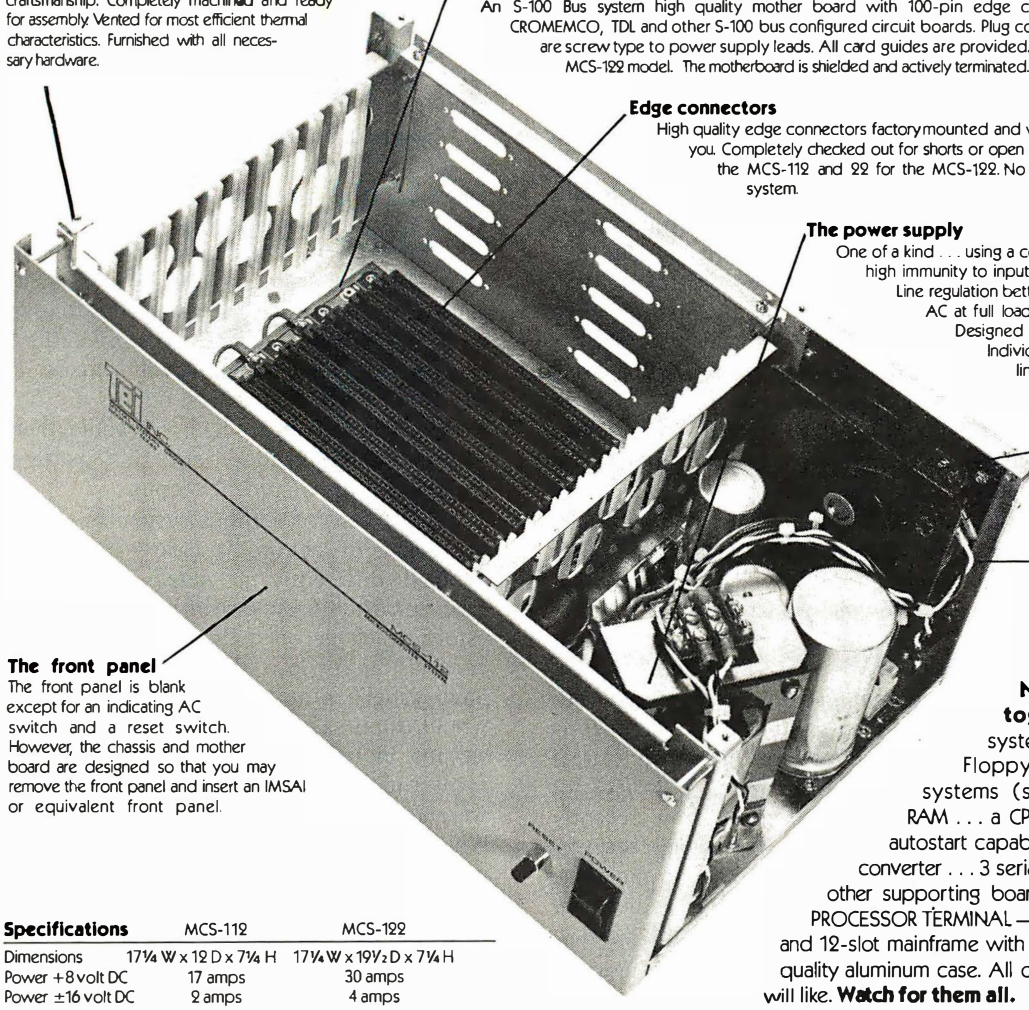
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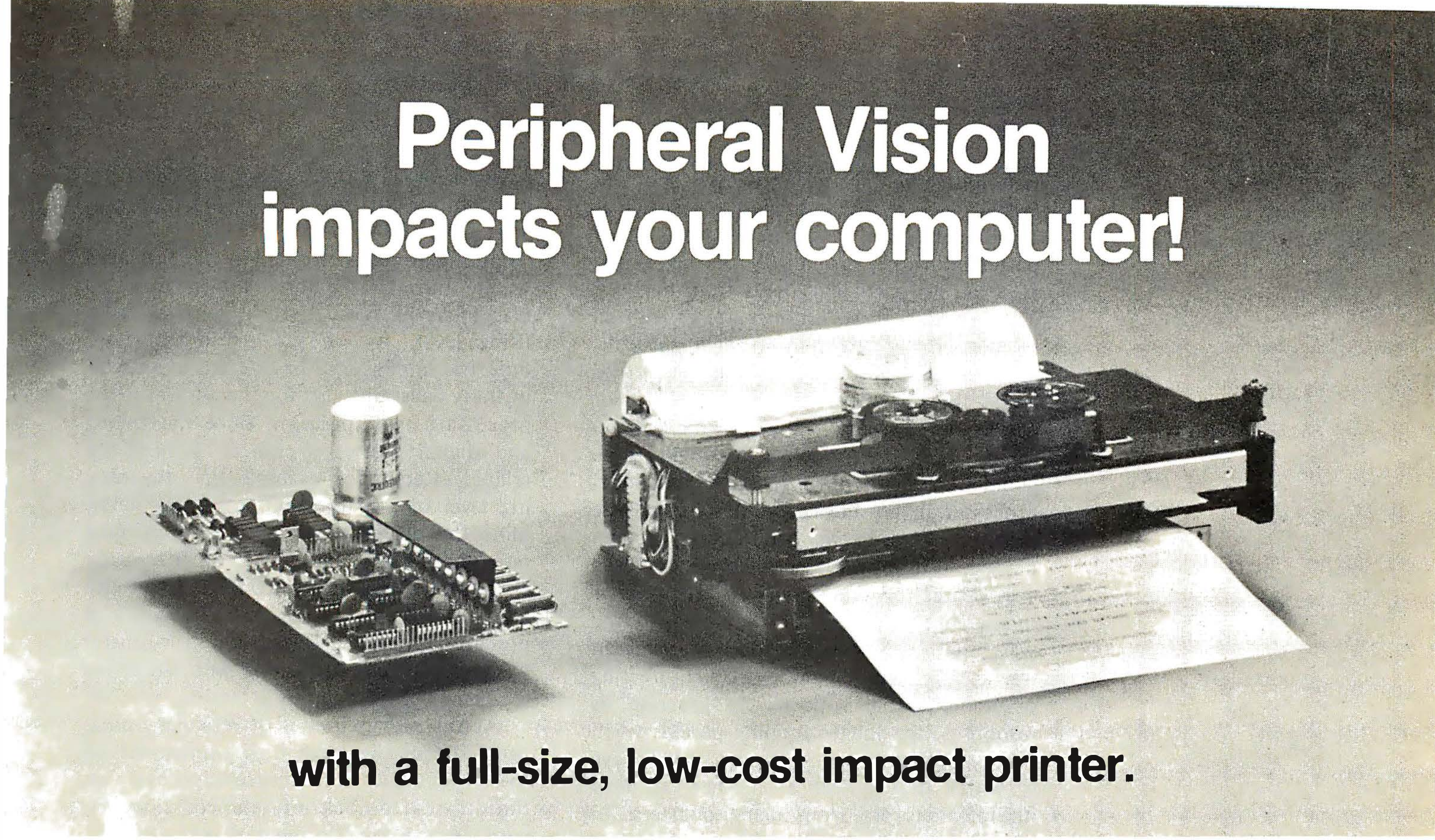
events at the basal ganglia: first the activation of a pattern of neural firing in the basal ganglia by cortical and thalamic inputs, and then a sustaining input from the reward system if the resulting behavioral output produces a more favorable stimulus situation with regard to goal related stimuli. Now any number of possible actions may be sent to the basal ganglia by the cortical mechanisms which are analyzing current events and memories of similar situations in the past. Some of these will be more successful than others in sustaining firing patterns in the basal ganglia. Remember the "self-quenching" action of the inhibitory elements in that structure. One function of this mechanism may be to insure that only one of the competing response patterns will emerge to direct the motor mechanisms. That is, the strongest input will most easily withstand the inhibitory action; and the inhibitory action which its own successful operation initiates will further undermine the attempts of competing firing patterns to seize the upper hand. Think of a bistable flip flop circuit when power comes on. Only one transistor winds up in the on state, and the other is completely off. In the same fashion, the mutually inhibitory actions of firing patterns in the basal ganglia would tend to insure that there was only one winner.

Just as in the case of the flip flop circuit, which one of the firing patterns wins may be determined by very minute differences in the ability of the competing activation patterns to fire their target neurons first. Furthermore, a variety of other factors (for example, how recently a particular neuron has fired) will cause the usual "winner" to lose some of the time. Thus, the patterns that emerge as behavior will have a ranking of probability; but it will never be guaranteed that one will always be the winner, only that it is the most likely to win. This is very different from most computer approaches, in which it is assumed that you know the best way, and do it that way always. In developing new behaviors to suit an unknown and changing environment, however, it is important to be able to experiment a little. Now if we could somehow alter the sensitivity of the target neurons a little bit in favor of one or another of the competing patterns so that that pattern could get a small jump on the competition, the probability of that pattern of behavior emerging as the victor would be increased. If this could be done in a way contingent on the behavior being "successful" (ie: activating the reward system), when by chance it was the winner, we would have all the features of operant conditioning.

It appears that this happens, and that at least with respect to complex, feedback controlled, environmentally-oriented behaviors, it does involve the basal ganglia. The process is called "reinforcement," and at the cellular level we don't know how it works. A reasonable guess, however, would be that it is essentially a process of classical conditioning of the cells of the basal ganglia by sequential activation by first the cortical and then the reward system's inputs. We know from studies of simple nervous systems that this classical conditioning mechanism, based on simple temporal contiguity of inputs, can occur within a single neuron when two inputs are activated sequentially. The operant conditioning process then may be the result of classical conditioning of certain cells, such as those of the basal ganglia, by inputs on the reward bus following firing by inputs from the cortical pattern generators. The resulting small increase in the ability of the cortical inputs to fire those particular target neurons would then increase the likelihood of that pattern emerging as the dominant output.

In the case of a robot system modeling this kind of action, it clearly would be handled differently in detail. One might easily envision a system in which the processors which decoded the equivalent of the cortical inputs into the equivalent of the basal ganglia outputs to the motor system would apply a numerical weighting to the various inputs received, and would increment the weighting if the "reward" input were active within a short period thereafter. What would be important would be the provision of some mechanism, perhaps a pseudorandom number generator, for making the predominance hierarchy probabilistic rather than absolute; and provision for changing the weighting according to the success of the behavior when tried. With these two features, the robot would achieve, within the limits of its behavioral capabilities, the flexibility and adaptiveness that characterize brains. It would also achieve their ability to make mistakes, but that seems to be a price that evolution has found acceptable.

I have presented this model of operant conditioning as though it were occurring exclusively in the basal ganglia. While this illustrates the general principle involved, it is clear that more is involved in the real brain. The projections of the reward system extend into large portions of the cortex, and it is clear that things other than the probability of output patterns can be modi-



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fied by similar learned processes. For example, the weight attached to particular stimulus features in generating the output patterns in the first place, or the weight attached to particular items from memory in generating these action patterns, can all be altered by the reinforcement process. Such things more likely occur at cortical levels than in the basal ganglia, and their details are obscure. However, there is no reason why the principles described here could not be applied to such functional processes in an advanced robot. Once the principle of operant conditioning is employed, it is possible in theory to achieve any degree of fine tuning of any process in the machine. It should be noted, by the way, that the more the machine relies on operant conditioning rather than hard wiring or unmodifiable software to generate its responses, the longer training period it will need, and the longer "infancy" it will have in which it will need a "mother" to keep its major errors from being disasters. In organic brains, the period of helpless infancy is directly proportional to the flexibility and adaptiveness of the adult brain, for just this reason.

Another important brain function, related to the concept of motivation in respect to energizing and directing behavior, is what is loosely referred to as "arousal and attention." There are two general types of arousal systems, and one depends on the other. The most fundamental is a general "tonic" arousal system. This term refers to the fact that the system sets the general level of activity in the nervous system over long periods of time, ie: it sets the "tone" of the system. The most important part of this system is a group of diffuse nuclei forming a long column in the central part of the spinal cord, medulla, pons and mesencephalon. This area is collectively referred to as the "reticular formation." One of the great early discoveries in brain function was the finding that the forebrain does not simply run of its own accord. It requires constant drive from the reticular formation to keep it processing. In this sense, the reticular formation acts like the brain's on/off switch. However, whereas most computers are either on or off, the brain is capable of operating at various levels of activation. Intuitively, you know the difference between feeling highly alert and excited, and feeling awake but inattentive and relaxed. This reflects different levels of operation of the forebrain, under control of the reticular formation. An imperfect analogy could be made with a computer having a variable clock speed, but even here, it is not strictly speed of processing that is affected. The general modulating inputs from the reticular formation connect very widely through the forebrain and serve to bias the cells there towards or away from firing level. As we saw earlier, this not only has implication for the rate of activity in these cells, but also for the nature of the processing they perform, since the analog and digital factors in the cell's input are related. Recall for example that the biasing level of a feature extractor may determine the degree to which the input must resemble the optimal input in order to cause an output. Thus, not only level of activity and speed of processing, but also nature of processing is affected, usually in a general way appropriate to dealing with situations requiring or not requiring attention.

At the two extremes of reticular formation control, we have high excitement on the one hand and unconsciousness on the other. (Do not confuse unconsciousness with sleep. Sleep is a separate *active* process that reflects a different type of organization of forebrain activity. We shall not discuss sleep, since I have yet to see any relevance of sleep to design of robot brains, and nobody knows what it's good for in humans either.) Part of the utility of such a system in a robot would be to conserve power when the environment was not demanding much attention. The power saving function is not inconsiderable in your own case either; the brain draws about 25 W, which is a healthy fraction of your available energy. A more important point is that the raised arousal levels provide a substrate out of which particular patterns of forebrain activity can be carved by selective inhibition. This is the process called "attention."

Let us first look at the sources of arousal. The reticular system is activated by three major types of input. One, which we have already dealt with in part, is the input from the mechanisms which detect and regulate motivational states. We mentioned there a general, nonspecific component to the arousal produced by motivational states. This appears to function through activation of the reticular formation by the motivational systems, or in some cases by the internal stimuli that activate those systems. A second source of control over reticular activation comes from the sensory systems. This occurs in a rather unique way. As the axons carrying sensory information through the brain to areas which analyze its contents pass by the reticular formation, they give off branches which contact cells

in the lateral part of the reticular formation (see figure 2). These cells in turn activate cells in the central portion of the reticular formation which give off long axons that carry the activation regulating control impulses to the rest of the brain. What is interesting here is that there is no attempt to keep the sensory input lines separate. Inputs from receptors for touch, sound, light and all other senses all synapse indiscriminately on the same neurons. There is thus no qualitative component to the reticular formation's input data, only quantitative. What it is responding to is the total amount of sensory activity in the receptors, or in other words, the general level of environmental "noise." Like all sensory systems, this one responds most strongly to things that change. Thus, abrupt changes in the level of activity at any sensory receptor will serve to activate the reticular formation and arouse the rest of the nervous system. Strange though it may seem, therefore, it is not the conscious perception of the sensory input which is arousing. In fact, if the reticular formation is damaged and the rest of the sensory apparatus is left intact, the organism will not be aroused by the most intense stimulation, even though electrical recording techniques show that the sensory information is getting to the sensory areas of the forebrain in full strength.

The function of this mechanism is clear: if there is a lot of changing activity in the environment, the organism probably needs to be alert and attending to it. The reticular formation is very old evolutionarily, and this mechanism probably represents one of the earliest types of response to the environment, one which is still useful even in the most advanced brains. If the process were to stop here, we would have an organism that could respond adequately to external events, but which would not be spontaneously alert in the absence of a need state or an external stimulus which required attention. This is approximately the behavior pattern of creatures such as amphibians and reptiles, which have little or no cortex. In the case of animals with a well-developed cortex, we see the development of a third set of inputs to the reticular formation, those from the cortex. This establishes a positive feedback loop between the reticular formation and the cortex which enables the cortical-reticular system to "lock on" and sustain its own activity. This development allows for control over arousal levels by the results of internal processing, and the brain is freed from dependence on need states or environmental input for activation. This is clearly advantageous when a level of cerebral sophistication has been reached which permits action on the basis of anticipated events. With this feedback loop, the more advanced brains achieve the capability for maintained conscious thought and regulation of their own operation.

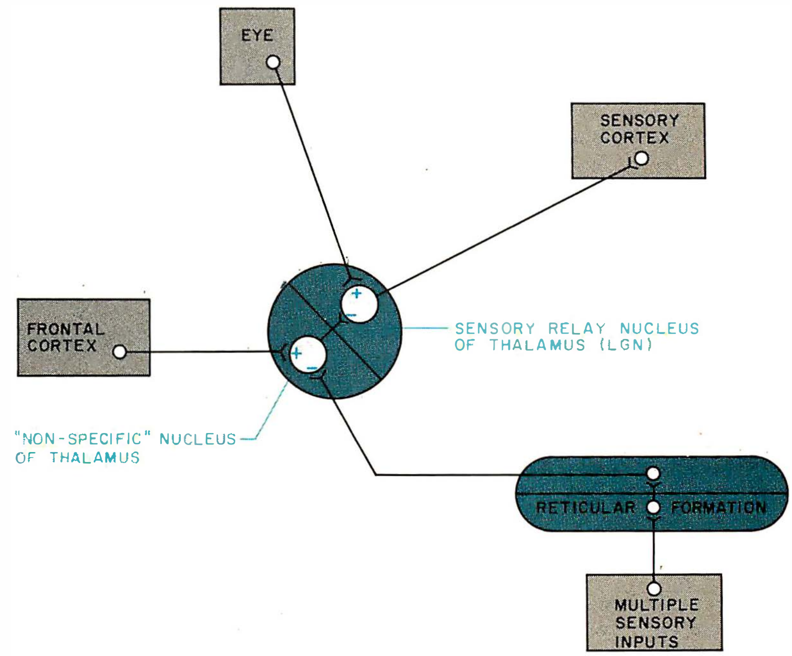


Figure 2: The brain's arousal and attention system. The reticular formation provides general arousal in response to several classes of input. The frontal cortex can focus the brain's processing by cutting selected systems out of the broad arousal provided by the reticular formation.

The other aspect to the control of arousal is one which allows the organism to focus its operation specifically on certain forebrain processes while shutting down others. That is, given a state of arousal or alertness to begin with, it is possible to channel this activation into particular functions. The operation of this mechanism is what we experience as "attention." In figure 2, notice that the projections of the reticular formation are shown having a facilitatory effect on a relay neuron in the thalamic nucleus (lateral geniculate) which is part of the pathway from the retina to the visual cortex. It does this by inhibiting a set of neurons in the so-called "nonspecific" nucleus of the thalamus which in turn normally inhibits the sensory relay neuron. Activity in the reticular formation thus tends to promote transmission in the visual system, as it does in other brain systems, and lack of reticular bias tends to shut it down. Now notice the input from the frontal cortex to the cells of the "nonspecific" thalamic nuclei. These have the opposite effect: they can counteract the reticular drive and shut down selected systems. In a similar fashion, the frontal cortex

and the reticular formation jointly control the operation of most forebrain systems. The way the process is arranged, the cortex does not directly activate any of the systems, but it can selectively oppose reticular activation. This means that given a general state of arousal activating the forebrain, the frontal cortex can manipulate the operation of various systems by cutting them out of the reticular activation, or permitting them to run. Thus, the frontal cortex can "carve out" a pattern of specific processing actions by selectively inhibiting what is not wanted. It thus is capable of orchestrating the operation of the higher processing centers, given the basic arousal by the reticular system. This process of attention has its origins in a hard wired reflex operation called the "orienting reflex" which shifts attention to, and has motor components which orient the receptors to, any strong novel stimulus. You experience this primitive mode of attention focusing when you reflexively spin around to face the source of an unexpected sound. At a somewhat more advanced level, the cortex can make use of the information from the motivational system to decide what stimuli or systems are "relevant" at the moment and focus processing activities accordingly. At the most advanced levels of operation, focusing of attention may be directed by the results of logical operations. Whatever the source of the decision, the process is the same.

The frontal cortex is the most advanced part of the brain system, and one of the roles it apparently plays is the organization of the activities of other systems to achieve high level operations. Presumably, the reason it operates by opposing reticular drive, rather than activating the forebrain directly, is because it is itself activated by the reticular system under the control of the factors just discussed. There may be no reason other than evolutionary sequence for not combining the two functions, although the initial general activation as well as the response speed of the reticular formation are a safety feature.

There is a general inhibitory system which can oppose reticular activation at all levels, and the frontal cortex initiated attention control is actually best viewed as the highest level of this general inhibitory system. Other lower processing units can contribute inhibitory control to this system at appropriate levels, and the actual pattern of activation of the brain at any instant is the result of an ascending activating influence from more primitive levels being modulated by a descending pattern of selective inhibition from more advanced levels. This is part of the general "fail safe" pattern of control which was described in the first article of this series. Loss of high command does not incapacitate lower centers, it frees them to operate independently as best they can. This is an idea that might be important in reliable robot brain design.

Analysis and Logic

What remains to be discussed is the brain's logical operation. This is of course one of the areas in which our current computers do very well already, and one where the brain frequently comes in second best. It evolved after all around control systems for chasing visible targets, and that doesn't require too much advanced thought. It is just as well, too, that our computers do well here because we really know very little about the brain's logical operations. Humans are best for that sort of investigation, and there are few volunteers for experimental brain surgery. There are a few points of interest, however, that may be worth scrutinizing. The first of these points emphasizes the utility of the brain's combined analog and digital, two-dimensional "byte" of temporal and spatial dimensions (Dare I coin the term "gulp"?). One of the real uses of such an arrangement, in which the intensity associated with each bit (axon) of the digital information is carried in analog form in the temporal dimension of that bit, is that you can operate logically and mathematically on those two aspects of the bit independently.

Consider what can be done if you have a set of lines which represent the output of the highest level feature extractors. These lines are the result of processing in cortical areas where the outputs from the various sensory modalities, already highly recoded, are brought together to generate information about the state of the external world based on a synthesis of the features extracted from all the available sensory data. Studies of brain damage in humans have given us some insight into the operation of these areas and the strange phenomena which can occur when their function is impaired. Things such as loss of the ability to name objects by sight while retaining the ability to draw them, or to name them by touch, are seen. A host of similar tantalizing bits of information are beginning to paint a picture of the functions of these areas. It appears that highly extracted information can be operated on here in a logical way, used to access memory, and even generate output. This, however, is actually prior to the operation of the highest levels of function which are concerned with extrapolation of the future course of

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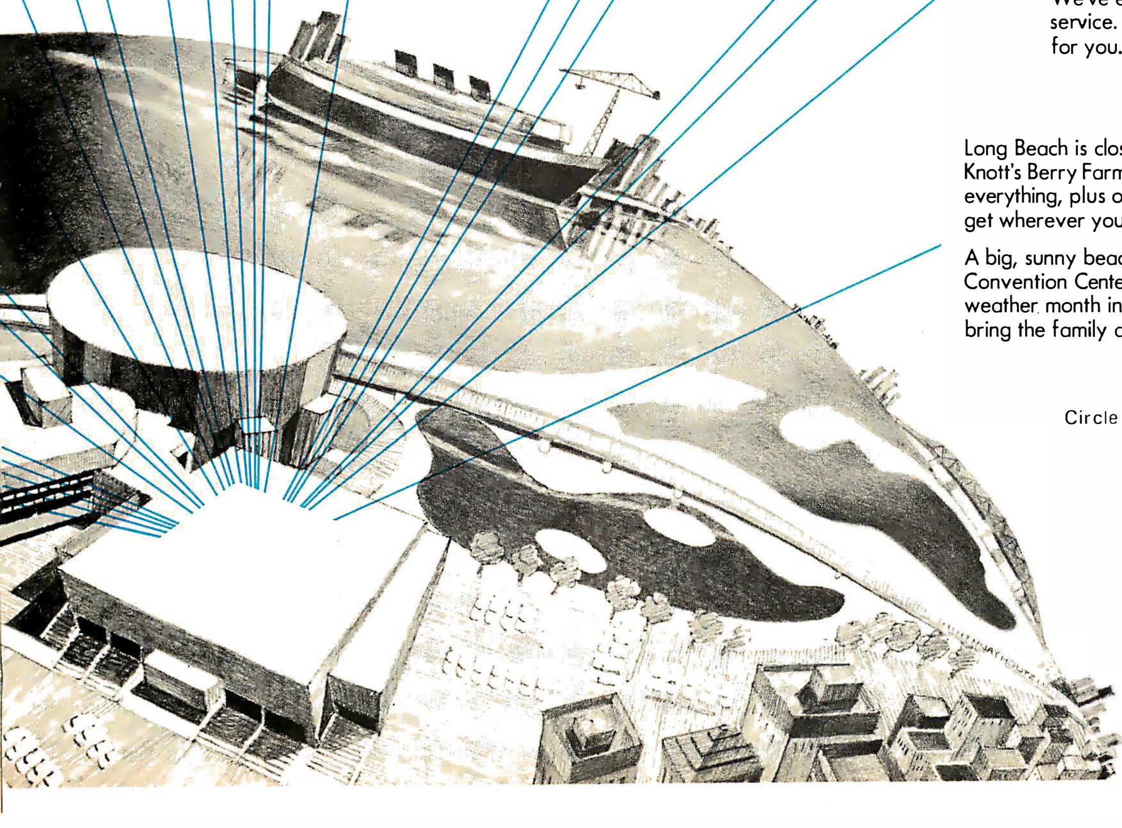
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events. If the spatial (digital) byte of this "gulp" of information encodes the state of the external world in its millions of bits, the analog (temporal) byte of the same "gulp" represents the current strength of activation of the feature extractors generating each of these bits. The rate of change of each feature with time can be obtained by differentiating the analog (temporal) byte on that line. This is easily done at the neural level by negative feedback from the cell's own axon, and does not affect the content of the associated digital word. Doing the process twice gives you the second derivative. If the whole collection of bits represents the state of the external world coded in terms of its cognitive features, the process produces the first and second time derivatives of reality, so to speak. These derivatives, added to the initial value, give the predicted next value of the analog (temporal) byte of the next state of the sensory world. It may be in error, but it is the best prediction from available data, at least without assistance from memory of past experiences. This means that it is relatively easy to extrapolate from moment to moment the future course of incredibly complex patterns of information. This extrapolation can be sent to the limbic system for analysis of the reward value of such a state of the world, and anticipatory action taken if necessary. The consequences of one's own actions can similarly be extrapolated by the same process applied to the current output commands. Of course, this simple process cannot be extended too far. It will only suffice for moment to moment sorts of operations, but these are exactly the real time applications that the more traditional approaches are too slow to handle. This is particularly true in the case of a system required to deal in real time with a generalized environment. The details of the process as I have presented them are highly speculative, but it is clear that something like this occurs, and the potential utility of the analog aspect of the "gulp" is clear in this regard.

Our present experimental evidence indicates that this type of ability, the ability to modify present behavior on the basis of extrapolated future events, is the province of the most advanced parts of the brain, such as the frontal cortex. This is particularly true of the ability to inhibit current gratifying behavior in anticipation of greater future good. The anatomy of the frontal cortex's connections suggests that it has all the appropriate links for operating in the way just described, as does its prominant role in inhibitory control of other regions. It is easy to imagine that following the development of a primitive extrapolative system such as the one described here, and the corresponding development of appropriate control outputs to express the corrections behaviorally, further refinements would include the development of logical and memory functions in the service of the extrapolator to improve capability for long term analysis. The development of such capability seems to be one of the advanced features that sets the brains of men apart from those of most animals. The ability to encode complex situations in symbolic form (as in words and numbers) undoubtedly aids enormously in this process. In terms of brain wiring, these processes are not well understood. Fortunately, computer technology is strong here.

The Importance of the "Almost" Gate

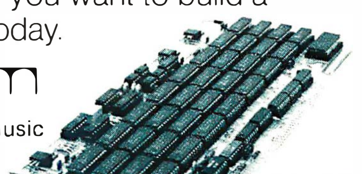
Two advantages derived from the nature of the brain's logic gates bear mentioning. What is noteworthy are some functions of the property I have nicknamed the "almost gate," that is, the production of an output pulse when some percentage of the inputs are active. The result of this operation of course is to allow the gate to fire in response to a number of different input patterns which only need be similar. For example, some but not all of the elements feeding a feature extractor may be fired by a similar feature. If it is similar enough it may work. This sort of operation underlies one of the important differences between brain memories and computer memories. When you access a word in a computer memory, you get back the contents of that word, period. Although the physical nature of the brain's memory storage mechanism is a mystery to us still, one thing that is clear about its operation is that a stimulus which matches an item in memory accesses not only that particular memory but also a host of similar items. This is an important tool, since "similar" items are those most likely to have important relationships to the problem at hand. Materials so accessed can of course be screened for relevance and in turn used to generate new memory calls. The development of this type of "associative" memory call in electronic hardware would go very far towards giving a robot brain much of the power of its organic counterpart. So long as the principle of selective convergence is used appropriately to generate the inputs for successive echelons of the "almost gates," it will be the case that the assortment of input patterns which can fire the final gate will have similarity along some important conceptual dimension. The outputs of such gates, when used to form



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memory addresses, would therefore access items associated in that dimension, ie: the same set of input lines would activate detectors for several "similar" input patterns. Of course with a conventional processor it would be difficult to handle the appearance of a number of memory words simultaneously on the bus, but there are a variety of ways to emulate brain architecture, from fast sequential processing to multiple processors handling memory control.

Finally, the "almost gate" mode of operation is probably responsible for that most impressive of all organic brain functions: the ability to make intuitive leaps that defy the constraints of formal logic. When a computer, as presently constructed, has insufficient data to arrive at a solution using acceptable logical procedures, that's that. But the brain's gates can get there without all the "proper" inputs. They can get there with some of the essential elements missing if the input pattern is similar enough to the correct one to get by the "almost gate." Thus, partial pictures of the state of the world can still suggest correct interpretations. Of course, they may be wrong; they have to be tested against reality. We make mistakes; computers don't. But the very feature of our processing that permits mistakes also enables us to go beyond the limitations of the data and make generalizations and intuitive leaps. In a machine with sufficient power to test its solutions against the real world, the ability to make mistakes is not so serious a price to pay for the advantages.

If you have come with me this far, you have seen what I know, or can guess, about some of the interesting relationships between the brain and the computer. What I would like to do in this closing section is to share with you some of the speculations of a brain scientist on that most fascinating of all questions that can be asked about a computer: "Could a computer designed by humans really think and feel emotions and be conscious?" It is a question without an answer of course; we can never know for certain about one another's subjective mental experiences, let alone those of a machine. The question belongs to philosophy, if anywhere, and I am not a philosopher. Working daily with the machine-like functions of brains, however, gives a certain perspective on the problem.

By this point it should be clear to you that, while we are far from understanding all of the workings of the brain, those that we do understand have turned out to be quite comprehensible in terms of machine-like functions. The fact that its gates are made of compounds of carbon and hydrogen instead of silicon and germanium is hardly reason to draw important distinctions. In my opinion there is nothing yet visible in the brain to suggest the presence, or necessity, of any nonmechanistic property in its operation. Yet there is the mind and the universe of subjective experience, which certainly seem to be nonphysical. On the other hand, the mind is certainly at least the "captive" of the physical brain. By appropriate electrical stimulation of your brain, I could cause you to feel rage, fear, joy or other emotions; I could cause you to experience hunger, or satiety, or any other motivation; I could cause you to remember forgotten events, to see or hear things that were not there just as realistically as if they were. All these things can be done by manipulation of the physical brain. They can be done by electrical methods, surgical methods or pharmacological methods, all of which are physical operations on a physical mechanical device. Yet, they surely and unerringly affect, even determine, the content of subjective conscious experience. I can vouch for it since I've done it (some of it) to my own brain.

Now if the mind is the "captive" of the brain in this sense, it must mean either that the mind is a nonphysical something whose nature and content is determined somehow by the state of the physical mechanical brain, or that the mind and the brain are one and the same thing. I prefer the latter notion simply because it requires fewer assumptions. It says that the subjective experience of our mental activities is simply the brain's perception of its own operations. According to this view, the operation of the visual feature extractors, for example, *is* the experience of the subjective visual perception. Not that the neural activity somehow causes or gives rise to the mental event, but that they are one and the same thing. The operation of the limbic system *is* the experience of emotion. The operation of the basal ganglia *is* the willing of an action.

The point of view incidentally is not necessarily "mechanistic" in the sense of proposing that the mind is physical in nature. It simply says that the mind which we experience subjectively, and the brain which we experience objectively through the senses, are one and the same thing experienced in two different ways. Whether that "thing" is a part of the physical world (which is a construction of our brain by inference about the subjective sensory experiences we have), or a part of the mental world which we experience directly, is indeterminate. They may even both be simply interpretations of something else.

All that is said is that the operation of the machine-like brain as we know it through the senses, and operation of the mind, are two ways of experiencing the same underlying process.

Now what does this imply about a computer? It certainly does not imply that anything that can produce behavior identical to that of a human being must therefore have a mind and subjective experience. As I have noted at other points in this series, our emotional experiences, subjective sensory experiences and other aspects of our minds are all paralleled by particular brain operations which have necessary and useful behavioral functions. A good robot needs an emotion circuit because it is helpful in generating and controlling adaptive behavior. A circuit that performs this function in the case of the robot, however, need not necessarily be associated with a subjective experience. Even if it caused an advanced robot with linguistic capability to be able to discuss its "feelings," it would only imply that the circuitry in question gave the device the ability to adjust its verbal output appropriately in accord with the conditions it encountered, in a way similar to our own.

On the other hand, if the brain's operation is the source of mental experience, and if the brain *is* a physical mechanical device, it follows that a computer of similar complexity *might* have subjective mental experiences. The question hinges on just how the operation of the brain leads to the occurrence of that set of subjective experiences we call a mind. If there is something unique about the particular operation of the particular sort of physical device we know of as a brain, and if that is a prerequisite for mental experience, then clearly no very different machine can have it. If on the other hand, the sort of subjective experience we know is simply a concomitant of certain kinds of self-sustaining information processing operations, regardless of the physical substrates performing them, then it would not matter how the device was constructed.

Thus, the fact that the brain is understandable in all its operations as a physical information processing device can only tell us that it may be possible for a computer to have subjective experience. Whether one ever does or not is not really an answerable question. I think that what it will ultimately come down to is that if our machines have the capability of interacting with us in a rational manner, and making comments that would indicate emotional experiences if made by another human, then we will come to feel that they have subjective experience and treat them accordingly. That, after all, is in the final analysis all that we know about one another.■

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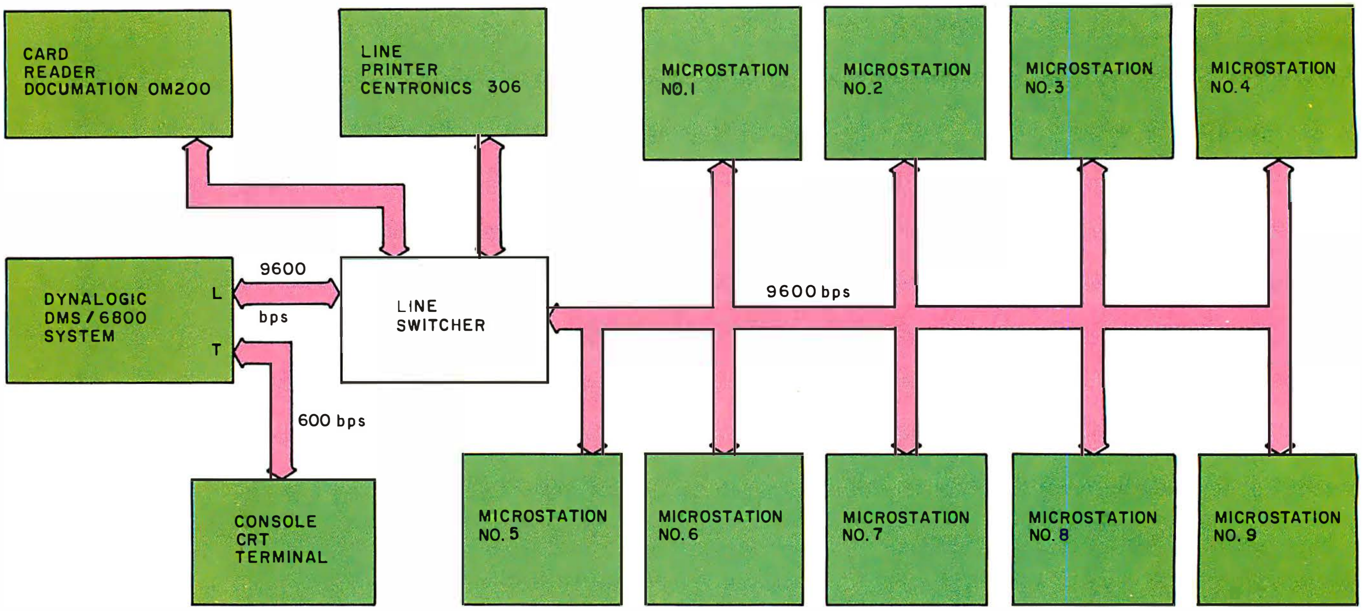


Figure 1 The system block diagram of the multiple microprocessor laboratory. This design allows each student team to have a separate dedicated computer with a shared set of peripherals controlled by the main system. The use of a common mass storage, printing and card input facility avoids the expense of having equivalent facilities at each student station. The "microstations" are small computers with limited (but still interactive) resources.

A College Microcomputer Facility

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200 Lees Av
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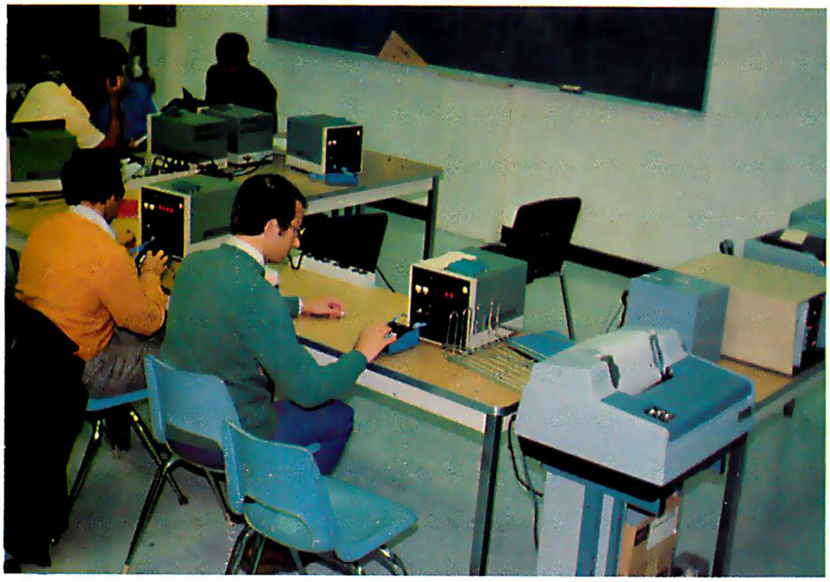


Photo 1: A group of students using the microprocessor laboratory described in this article.

If a student were asked to design a lab facility for a course in microprocessor hardware and software at the college level, the equipment list could be formidable. From the student's viewpoint there should be one computer per student or pair of students, with quick and simple edit capability, fast assembly, instant hard copy and a source file that nobody else can erase. Other desirable features could be serial, parallel and bus access to the computer for hardware projects, access to callable IO routines, and simple system operation that would not need an operator. With a budget of less than $20,000, the system first planned by the faculty at Algonquin College in Ottawa CANADA lacked many of the above features. However, by use of fast, shared input-output equipment plus simple multipoint network communications, such a facility was designed and implemented in eight months within the $20,000 budget. Approximately 100 students in seven separate lab groups used this facility at Algonquin College during 1977. Photo 1 shows some of the students, each in front of one of the microcomputer stations. Figure 1 shows the system block diagram, including the main computer, a Dynalogic DMS/6800

system with dual diskettes, and the nine bus connected microstations, each a stand alone college-built Motorola 6800 microcomputer.

Student programs written in assembly language are entered via data cards, either punched or mark sensed, and are assembled at the Dynalogic main station, which also runs Algonquin's batch software program. Listing of programs is optional, controlled by the students. The assembled program can be executed right in the main station or down-line loaded over a common data bus to one of nine microstations. Each microstation is essentially a 6800 microcomputer with keyboard and LED display, where hardware projects can be interfaced and debugged via software or lab test equipment. Details of the microstations are discussed later. A typical 50 card program can be read, assembled and transferred to one of the microstations in less than 20 seconds. If a listing is also needed, the time would be about one minute; hence the system very easily supports lab sized groups of up to 16 students.

One might wonder why the card reader approach was taken in the design of this system. Aside from the much reduced cost compared to diskettes and low speed terminals at each station, the card reader eliminates the time lost in learning the system operation details and the intricacies of an editor, which is a high overhead for a new student in a 1 semester course. Card input permits errors to be corrected quickly and also permits the student to have full control over the source file. The mark sense option permits students to prepare programs anywhere, an advantage to night school students who may not have access to a card punch between weekly classes. On the output side both time and costs are saved by using one medium speed printer (100 characters per second), rather than many low speed hard copy terminals, such as Teletypes.

This facility was available on an open shop basis to all students from 8 AM to midnight daily, except during scheduled lab periods. After the first week the students operated the system without help, with only a few hours lost during debugging of new system software and hardware. The Dynalogic DMS system itself operated without failure of any kind during 1977.

Program Format and Operation Details

Program format is one instruction per card using the Motorola 6800 assembly language. One job card is required to control the destination of the assembled program. On it the job terminator (&) is followed by a single digit, 0, for the main system, or 1 to 9 for the appropriate microstation. After the card deck is read, the assembler offers the student the option of listing or no listing, the only necessary response during batch operations.

If the program's object code is to be transferred to one of the microstations, the station's number is then announced on the console video display. If the microstation's receive program is already running, the file is transferred after handshaking between the main station and the appropriate microstation. If the microstation's receive program is not yet running, the main station will continue handshaking attempts along with a repeated console announcement of the destination until the microstation responds, after which down-line loading begins. At 9600 bps, most files are transferred in less than 1 second. Striking K on the console keyboard during listing or while waiting to down-line load an object file will kill the student's job, automatically starting the next job.

At a particular microstation, a fresh copy of the object code is sometimes desirable, particularly during debugging operations. Typing L5 on the main station's keyboard reloads microstation #5's most recent object file from the main station's diskette, eliminating the necessity of reentering a card deck. Programs executed in the main station have available to them an extensive set of callable routines, such as OUTMES, which outputs a user message on the console CRT, and INTERM which inputs a character from the console keyboard, plus a set of read and write routines for the diskette.

Hardware

Figure 1 shows the two serial ports on the main computer station, the 600 bps terminal port connected to the console terminal, and the 9600 bps line port. Under program control, the line port can be steered by the line switcher to communicate with the card reader and line printer or to the "microbus," an RS-232-C serial bus connected to all nine microstations. The line switcher box also contains hardware for parallel interfacing of the card reader and line printer, as well as code conversion hardware for the card reader's output, converting either mark sense code or 029 punch code to ASCII. The microbus uses standard RS-232-C signals, but with secondary channel pin assignments at the microstations, per-

Acknowledgements

Our sincere thanks go to Sam Zemlak and Andy Ouellette who constructed and tested the line switcher and the nine microstations.

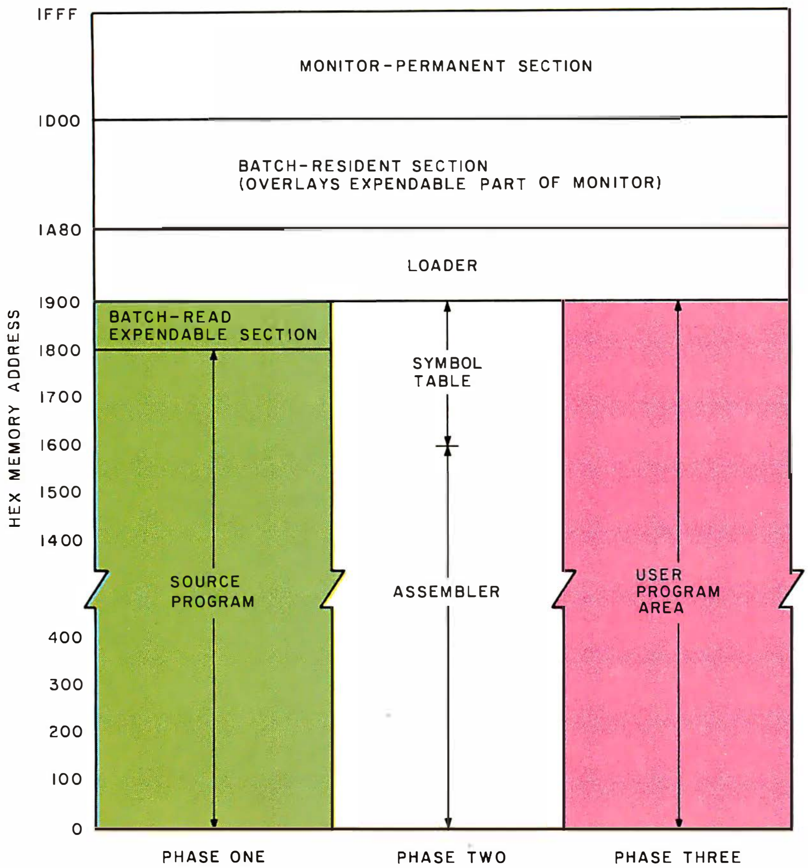


Figure 2: The main station which controls the entire system has this memory map in its 8 K byte region of programmable memory. The three phases of a batch processing operation of a given student's job are shown as a horizontal dimension of the memory map.

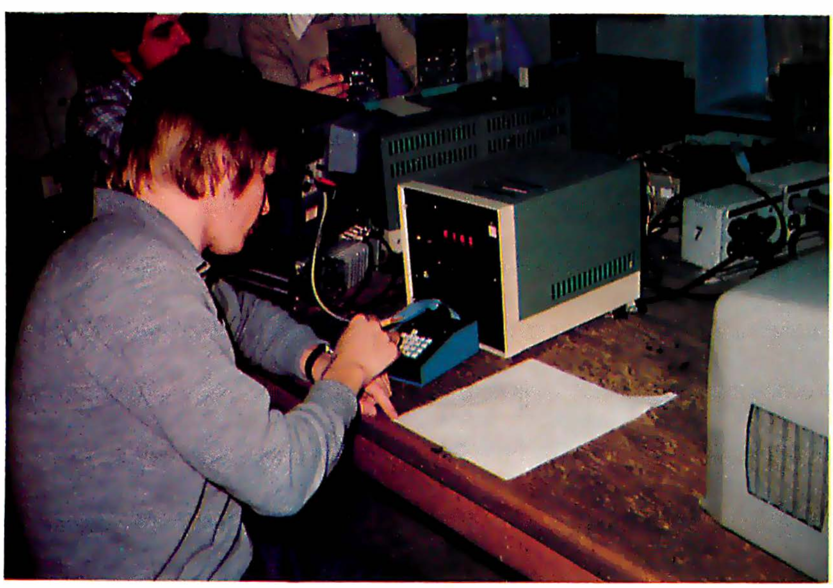


Photo 2: A closeup of a typical microstation with a student busy using it.

mitting the use of normal RS-232-C pin assignments by the microstations for their own serial communication with other devices.

System Software

The batch software is essentially DYNAMO, the Dynalogic monitor, extensively overlaid to support batch operation. Figure 2 shows the 8 K memory map during three main phases of the batch cycle. During phase 1 we see the source program in memory, as read from the card reader, before it is written out on the diskette. Phase 2 shows the assembler now in memory as it reads the source file and outputs the object file to the diskette. The symbol table builds up from address 1640, the top of the assembler, and may overwrite batch's read routine which is expendable after phase 1 is completed. Up to 90 symbols are permitted. During phase 3 the object code is transferred from the diskette to the appropriate station. A program executed in the main station can use up to 6 K bytes of programmable memory (hexadecimal addresses 0000 to 18FF) and is written as a subroutine which returns to batch upon completion. Batch itself is automatically refreshed from the diskette before the next job, ensuring clean code even if it was previously overwritten by the symbol table or by a runaway student program.

Figure 3 shows the diskette track allocations. Batch itself is stored on track 76. The latest source file, up to 6 K bytes long, is stored on tracks 74 and 75. The object code is stored on tracks 64 to 73, with one 4 K byte track being assigned to each microstation. This permits the reloading of an object file, as mentioned previously.

Microstation Operation

Photo 2 shows a student working at one of the microstations. Each of the nine microstations is essentially a stand alone microcomputer complete with 2 K bytes of programmable memory and several levels of hardware interfacing. Debugging of the hardware can be carried out via programs down-line loaded from the main station or via short routines entered on the 17 key keypad (shown in figure 4). A 4 digit LED display provides visual feedback to the student in either case.

Receiving and running a program loaded by the main station is relatively simple. The designated microstation is set into the receive mode by depressing the control (CTRL) key followed by the receive (RCV)

key on the keypad. (Throughout the rest of this article, a sequence such as this will be denoted as CTRL RCV.) The microprocessor will then receive the program only after the handshaking sequence takes place. When loading is complete, the hexadecimal starting address of the program is announced on the microstation LED display. CTRL GO will start execution of the program.

Manual Program Entry

Students are encouraged to enter short programs via the keyboard directly in hexadecimal to improve their skills in using machine code. The initial starting address is set up by CTRL LA followed by a 4 digit hexadecimal address. The program is automatically loaded into consecutive memory locations by CTRL LD followed by a series of 2 digit hexadecimal numbers.

Program Debug

A large variety of hardware and software tools have been provided for debugging programs. These debug aids allow the students to trace through a program, stopping wherever necessary to look at internal registers and external IO conditions.

A program can be checked by reloading the starting address and pushing CTRL XD. Each time XD is pushed thereafter, the next byte of machine code is displayed and the program counter is incremented. If at any time an error is discovered, CTRL CH decrements the program counter and allows the student to change a byte. Besides providing a quick means of loading and checking machine language programs, the above mentioned keyboard control also allows the student to do hardware checks. Since input and output ports look like memory locations in the 6800 system, a student can load and examine data at these locations and determine whether a hardware interface is functioning properly.

Each of the internal registers of the machine can be examined at any time by pushing CTRL ST (assuming that the program has stopped and the microstation is now under keyboard control). The stack pointer, condition code register, accumulators A and B, index register, and program counter are each displayed in turn as ST is pushed. Further flexibility is provided by the single instruction (SI), go trap (GT), and software interrupt instructions which permit controlled return to the user at specific points in the program. Some of the features of these routines are described below.

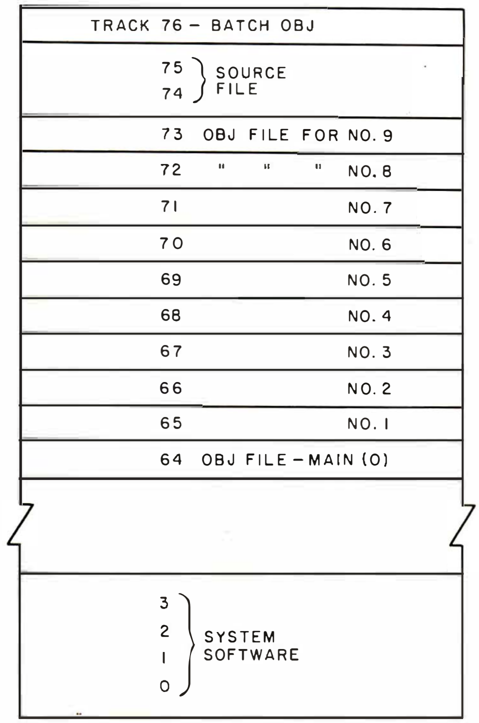


Figure 3: Allocation of the mass storage on a floppy disk. In order to allow quick reloading from the microstations, the current microstation object file is kept for each microstation, dedicating one track per microstation and one track to the main computer's object file. Thus if a program blows up in a student's system, it can be reloaded (and patched) without reassembly.

Controlled Execution: SI and GT

Single Instruction Routine (SI)

CTRL SI executes a single instruction of the user's program and returns to keyboard control. The address of the next instruction to be executed is displayed on the hexadecimal LED display. Thereafter, each time SI is pushed, an additional single instruction will be executed. Two modes of single instruction are available, each of which can be entered at any time by setting or resetting a flag via the keyboard. The first mode (default mode) returns to the user after each executed instruction, except for subroutines, where return to the user occurs only upon subroutine exit. The second mode, which is entered by depressing CTRL F on the key

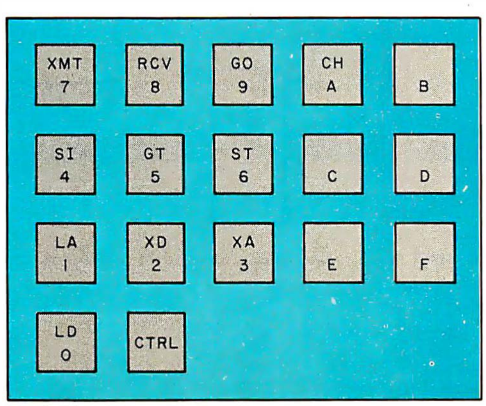


Figure 4: Detail of a microstation keypad. The normal mode of operation is hexadecimal input; when the CTRL key is followed by any other key, one of the 11 special functions (see text) is performed.

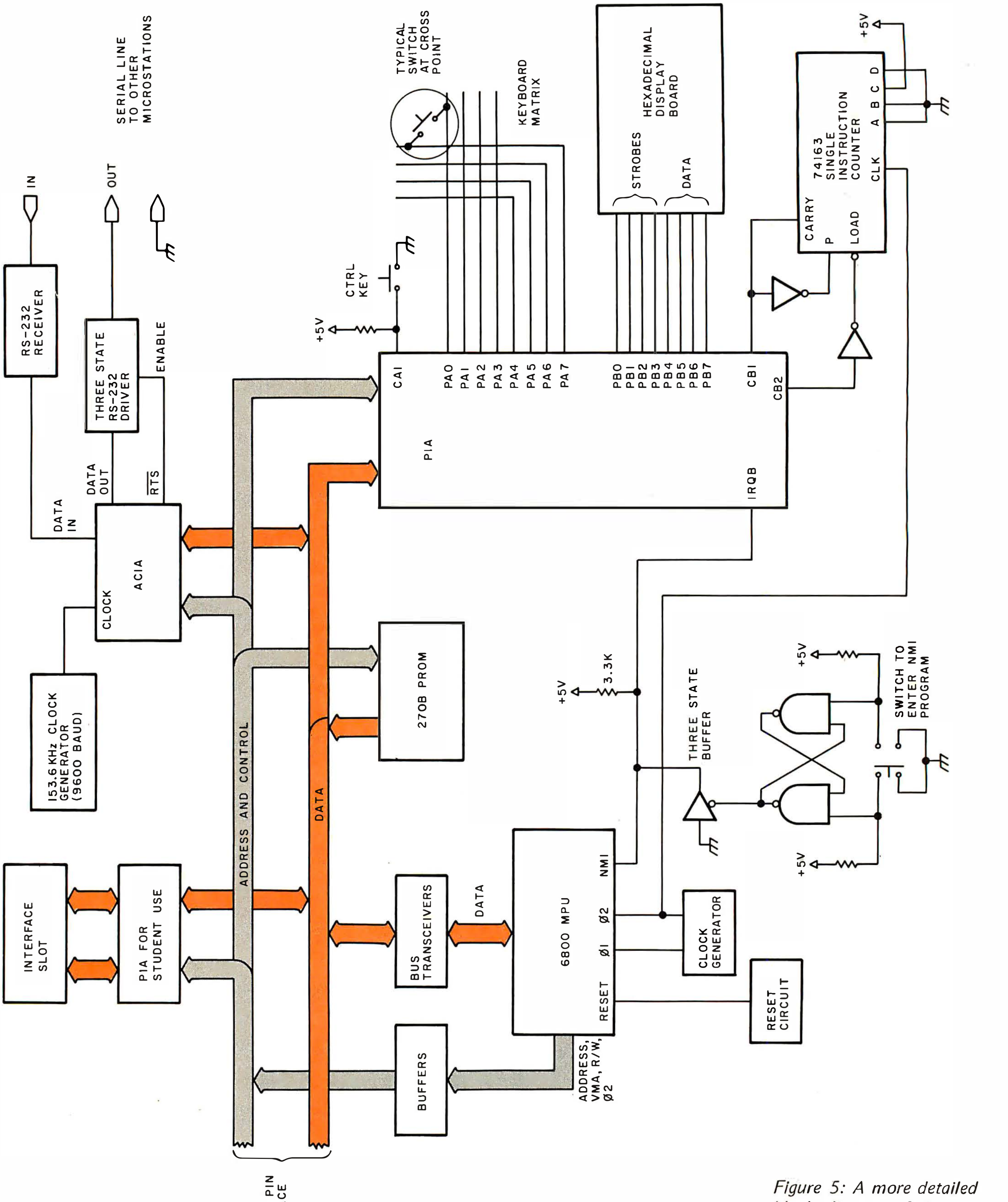


Figure 5: A more detailed block diagram of the system's microstation hardware.

pad, executes each instruction separately, including those of the subroutine. Return to the first mode is accomplished by CTRL E.

Go Trap Routine

This is a breakpoint setting routine which can be invoked at any time by CRTL GT plus a trap address. The program runs from the present program counter value and continues until it reaches the trap address. This routine permits the student to check out a specific section of a program.

Software Interrupt Routine

This is a user subroutine which, when called, simply returns the program to keyboard control. The student can insert these subroutine calls inside the program. A keyboard control feature allows him or her to ignore some or all of these breakpoints. This routine is particularly useful for debugging interrupt programs.

Hardware Interfacing

Serial data devices can be interfaced to the microprocessor via a standard 25 pin connector connected to an asynchronous communications interface adapter (ACIA). Parallel interfacing is provided via a 44 pin connector and a peripheral interface adaptor (PIA). Students who wish to design their own interfaces can connect directly to the microprocessor's bus via two 44 pin connectors.

Implementation

A block diagram of the necessary hardware for the system is shown in figure 5. In actual fact more hardware was used because the Motorola Evaluation module was also part of the system. The 2708 erasable programmable read only memory contains the system software which is accessed via the nonmaskable interrupt (NMI) instruction. Initially the NMI is caused by the user pushing a button on the front panel of the microstation. The beginning of the interrupt routine initializes peripherals, waits for the control key to be pushed, and jumps to one of the control programs based on the encoded value of the next noncontrol key. These control programs are discussed separately below.

LA, XA, LD, XD and GO Programs

These programs involve the program counter (PC) in some way. Setting up or examining the program counter cannot be achieved directly in the 6800 because no instruction permits it. The user's program counter can be set up only during an interrupt of the user program. At this time the user's counter is stored on the stack (see figure 6). It can be located without changing the stack pointer by transferring the stack pointer to the index register using the TSX instruction. Locations (5, X) and (6, X) now contain the counter value which can be examined or changed at will. Once the program has been loaded, the student can run a program by doing a CTRL GO, which causes a return from interrupt to occur.

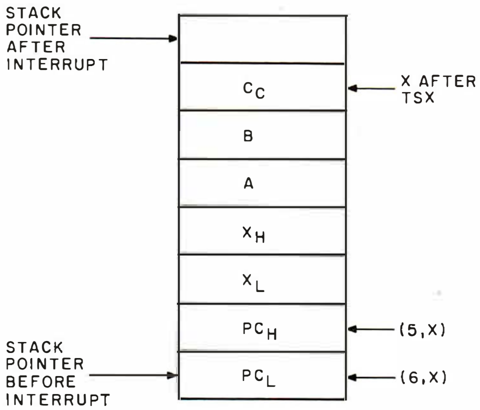


Figure 6: The stack frame after an interrupt in a Motorola 6800. In order to reference the stack frame, the content of the stack pointer is transferred (and incremented in the process) to the index register, which ends up pointing to the stack frame's first element.

Debug Routines: ST, SI, GT and Software Interrupt

Stack Routine (ST)

When a program is interrupted, the contents of all the registers are stored on the stack. A CTRL ST permits the examination of each of these registers. This is done by moving up the stack and outputting the contents of each register on the LED display. Further movement up the stack allows the student to look at previous activity on the stack. The stack pointer is displayed at the beginning of the ST routine, permitting the student to follow this activity.

Single Instruction Routine (SI)

Here the user program is started, but interrupted after execution of the first instruction. This is done by loading the single instruction counter (see figure 5), allowing it to start counting, and then performing a return from interrupt (RTI) instruction. The RTI instruction takes ten cycles, after which time the user's program will start running. The counter is designed to cause a nonmaskable interrupt (NMI) after 11 cycles, which will be exactly one cycle into the user's program. Thus the NMI

will return the microstation to keyboard control as soon as the first instruction of the user's program has been executed.

Go Trap Routine (GT)

This stores the trap address and executes continuous single instructions until the program counter equals the trap address.

Software Interrupt Routine

Motorola's SWI instruction was not used to provide this function because the MIKBUG read only memory vectors the software interrupt to its own breakpoint routine and thus makes it unavailable to any other firmware in the microstation. In order to provide the equivalent of the SWI instruction, a software interrupt subroutine is made available to the user. This subroutine uses the single instruction counter to cause an interrupt.

RCV Program

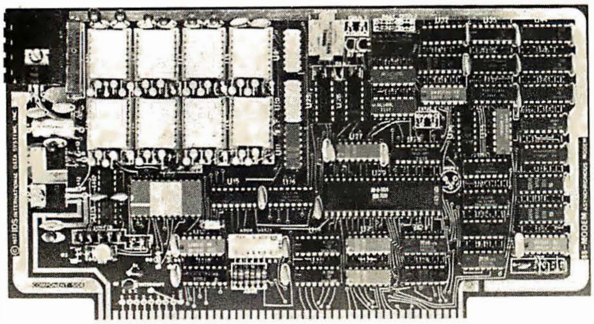
Our receive program is similar to Motorola's MIKBUG Load routine with a few added features. One feature is the handshaking. The microstation must receive a microstation identification number and reply with the same number before it can receive data. Since all the microstations are on a common bus, a transistorized three state RS-232-C output is provided for the line. Another feature of the RCV firmware loads the address of the first data block into the program counter (via the stack) and returns the microstation to keyboard control so that CTRL GO causes immediate execution of the program.

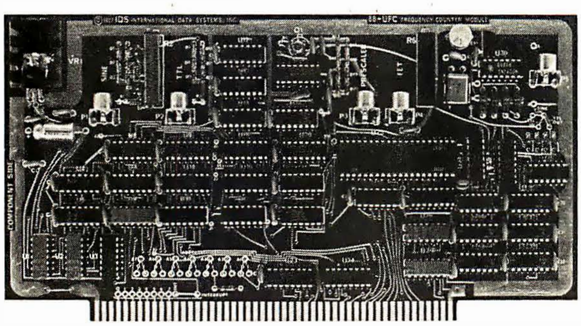
Future Plans

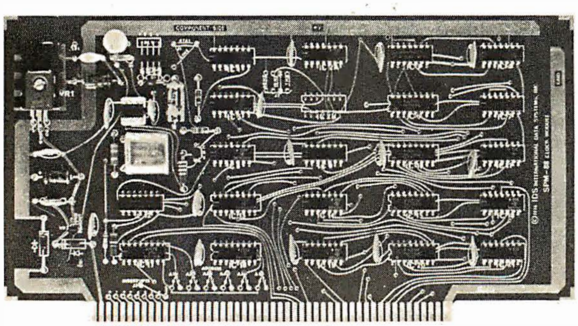
An Altair 8800 with a resident assembler has been acquired to act as one of the microstations. It will receive and assemble 8080 source programs that have been sent from the card reader via the microbus and will then provide a listing to the line printer if so desired. Finally, it will either run the job locally, inside the Altair computer, or will down-line load the object file to one of eight 8080 microstations that will be located on a second microbus.

Summary

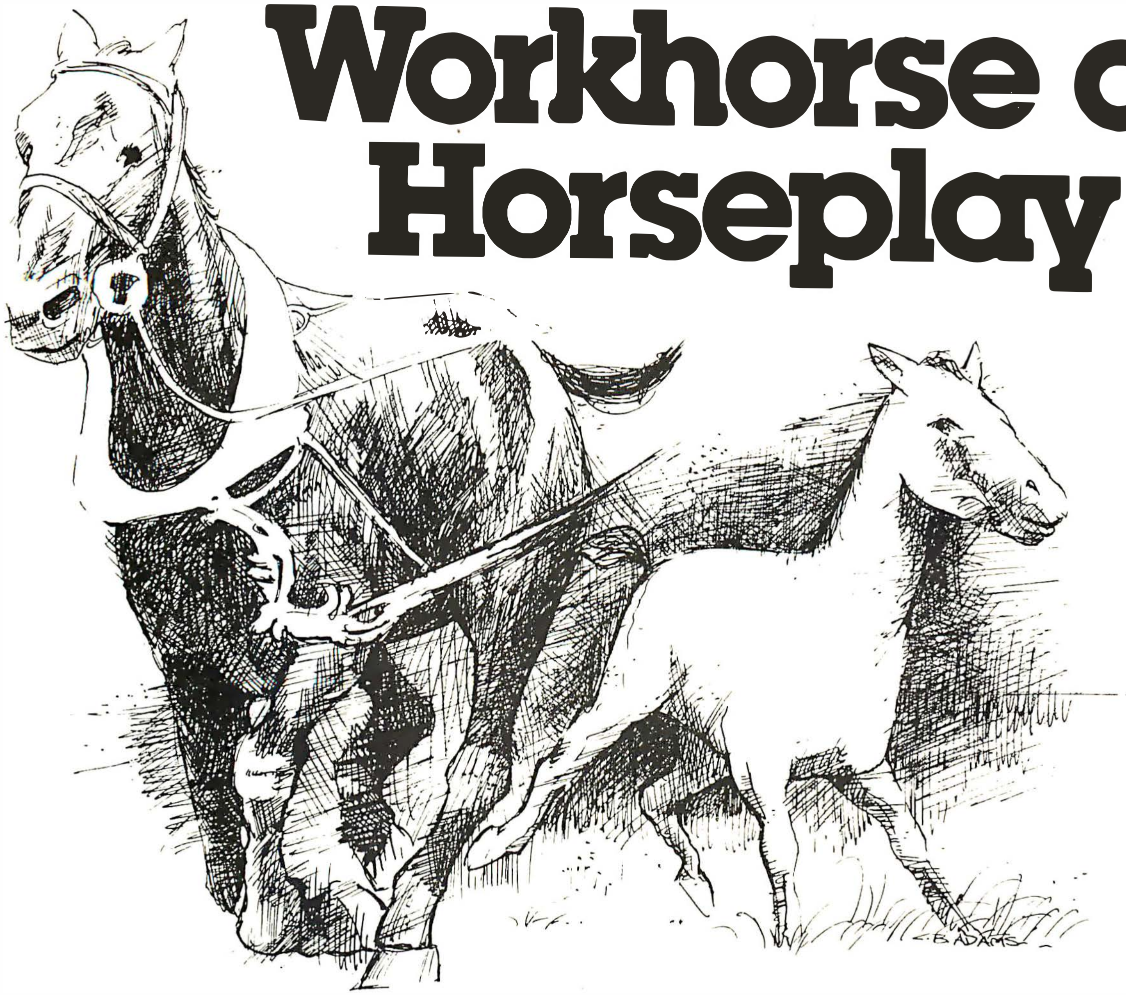
The final acceptance test of any system is always provided by the user, who in this case is the student. The students' reactions have been very positive judging from the way they handle complex software and hardware projects on the system during the semester.■







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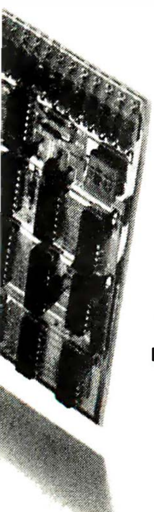
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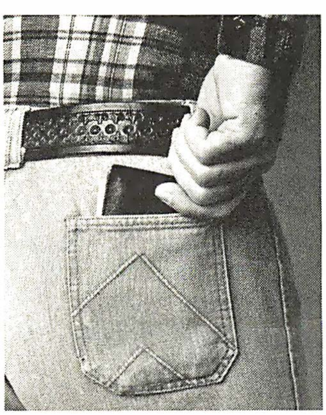
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Listing 4: 16 bit integer multiplication; only the rightmost bits are retained, making this multiplication also valid for 16 bit unsigned integers. If I1-I3 are in lower 255 bytes of memory, the product will be formed in about 140 machine cycles. The stack, index register and operands are all unchanged.

```
           801C  FM      EQU    $801C
           801D  SM      EQU    FM+1
           801E  URP     EQU    SM+1
           801F  LRP     EQU    URP+1
      0000 0002  I1      RMB    2
      0002 0002  I2      RMB    2
      0004 0002  I3      RMB    2
      0100                ORG    $100
                 *
                 *       SUBROUTINE MPY16T
                 *
                 *       PURPOSE:  TO MULTIPLY TWO 16 BIT
                 *       TWOS COMPLEMENT INTEGERS GIVING
                 *       A 16 BIT TWOS COMPLEMENT RESULT
                 *
                 *       PARAMETERS:
                 *
                 *             I1 -- TWO BYTE FOR ONE MULTIPLICAND
                 *             I2 -- TWO BYTE AREA FOR OTHER
                 *             I3 -- TWO BYTE PRODUCT
                 *
                 *       RESTRICTIONS:
                 *
                 *       ACCA AND ACCB ARE DESTROYED
                 *       USES HARDWARE MULTIPLIER
                 *
      0100 86 06  MPY16T LDA A  #6        SET MULTIPLIER TO
      0102 B7 801E       STA A  URP       STRIP BOTH SIGNS
      0105 96 01         LDA A  I1+1      FORM PRODUCT OF
      0107 B7 801C       STA A  FM        SIGN STRIPPED
      010A D6 03         LDA B  I2+1      A2 AND B2
      010C F7 801D       STA B  SM
      010F B6 801E       LDA A  URP       STORE IN I3
      0112 97 04         STA A  I3
      0114 B6 801F       LDA A  LRP
      0117 97 05         STA A  I3+1
      0119 7F 801E       CLR    URP       CLEAR STRIPPER
      011C F7 801C       STA B  FM        REMEMBER B2 IS
      011F 96 00         LDA A  I1        IN ACCB
      0121 B7 801D       STA A  SM        FORM B2*A1
      0124 B6 801F       LDA A  LRP
      0127 9B 04         ADD A  I3        ADD TO PRODUCT
      0129 97 04         STA A  I3
      012B 96 02         LDA A  I2        FORM B1*A2
      012D B7 801C       STA A  FM
      0130 96 01         LDA A  I1+1
      0132 B7 801D       STA A  SM
      0135 B6 801F       LDA A  LRP
      0138 9B 04         ADD A  I3        ADD TO PRODUCT
      013A 97 04         STA A  I3
      013C 96 01         LDA A  I1+1
      013E 0C            CLC              PREPARE FOR ROR B AT ONLYA
      013F 5D            TST B            BETA 8 SET?
      0140 2D 04         BLT    TRYA2
      0142 4D            TST A            ALPHA 8 SET?
      0143 2D 05         BLT    ONLYA
      0145 39            RTS              WE GOT LUCKY
      0146 4D     TRYA2  TST A            ALPHA 8 TOO?
      0147 2D 0F         BLT    BOTH
      0149 16     TABMPY TAB
      014A 56     ONLYA  ROR B            SHIFT RIGHT
      014B 24 06         BCC    ZOUT      ONE OUT?
      014D 86 80         LDA A  #$80      YES - ADD IT
      014F 9B 05         ADD A  I3+1      TO LEFT PRODUCT
      0151 97 05         STA A  I3+1
      0153 D9 04  ZOUT   ADC B  I3        ADD REST TO
      0155 D7 04         STA B  I3        LEFT PRODUCT
      0157 39            RTS
      0158 1B     BOTH   ABA              UNLUCKY CASE
      0159 8B 80         ADD A  #$80      ADJUST CARRY OUT
      015B 20 EC         BRA    TABMPY
                         END
```

Continued from page 35

the adding), which is not even a negative number (considered as a 14 bit product plus sign). Extending the most significant 1 to the left seems to help at first until one considers the problem 30 X 17: as 8 bit numbers, we have 30 = 00011110, 17 = 00010001 and their multiplication by the above scheme gives the same 000000111111110; since no one would agree that 510 = −2, something must be wrong. A clue was mentioned earlier, something about leading ones being insignificant for negative numbers. Sure; well, at least it's worth a try.

Let's create 16 bit numbers from A and B by extending the sign bit of each to the left eight bits, and carry out the usual unsigned binary multiplication algorithm on these 16 bit numbers (keeping only the rightmost 15 bits). The product will be the correct (except for overflow, which results in −128X −128 "=" −16384) 14 bit two's complement number plus sign. In algorithm 1, this process is described; M6800 assembly code is given in listing 3 to implement this logic.

Integer Arithmetic

The multiplier we used for fast addressing performs the function just described, multiplication of two 8 bit two's complement numbers giving a 14 bit product plus sign. We now consider application to fixed point arithmetic. We start with 16 bit two's complement integers; the PDP-11 series of minicomputers, for instance, and some versions of BASIC have integers of this type. In an 8 bit computer, such an integer A is stored in two successive bytes, say A_1 and A_2; we must also speak of the bits in A, say $\alpha_0\alpha_1 \ldots \alpha_{15}$ and the number a_2 formed from A_2 by replacing α_8 by 0 (ie: $a_2 = 0\ \alpha_9 \ldots \alpha_{15}$). In figure 4, we display the product of two numbers A and B represented this way without the αs and βs.

On the left, we display in a vertical column the subscripts of the β_j, and next to each j the subscripts of the α_i which β_j multiplies. The product is formed by summing each vertical column with carry. We can see much of this pattern is made up of parts of an 8 bit two's complement multiplication: for example, the part in the upper right corner is a_2b_2 (recall a_2 is the positive two's

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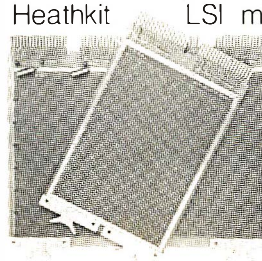
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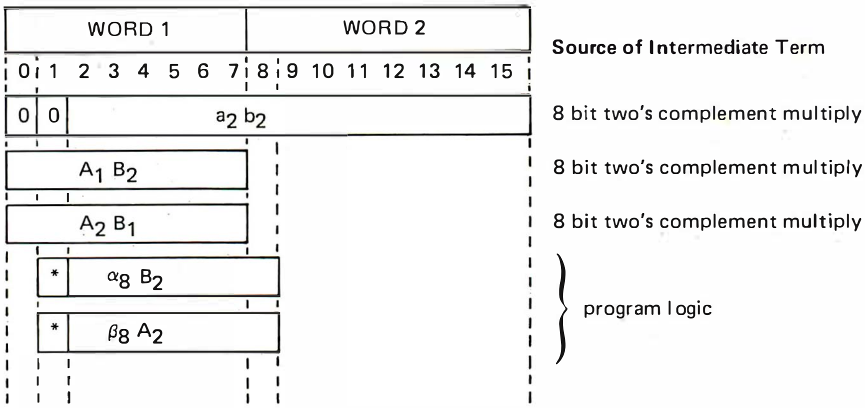
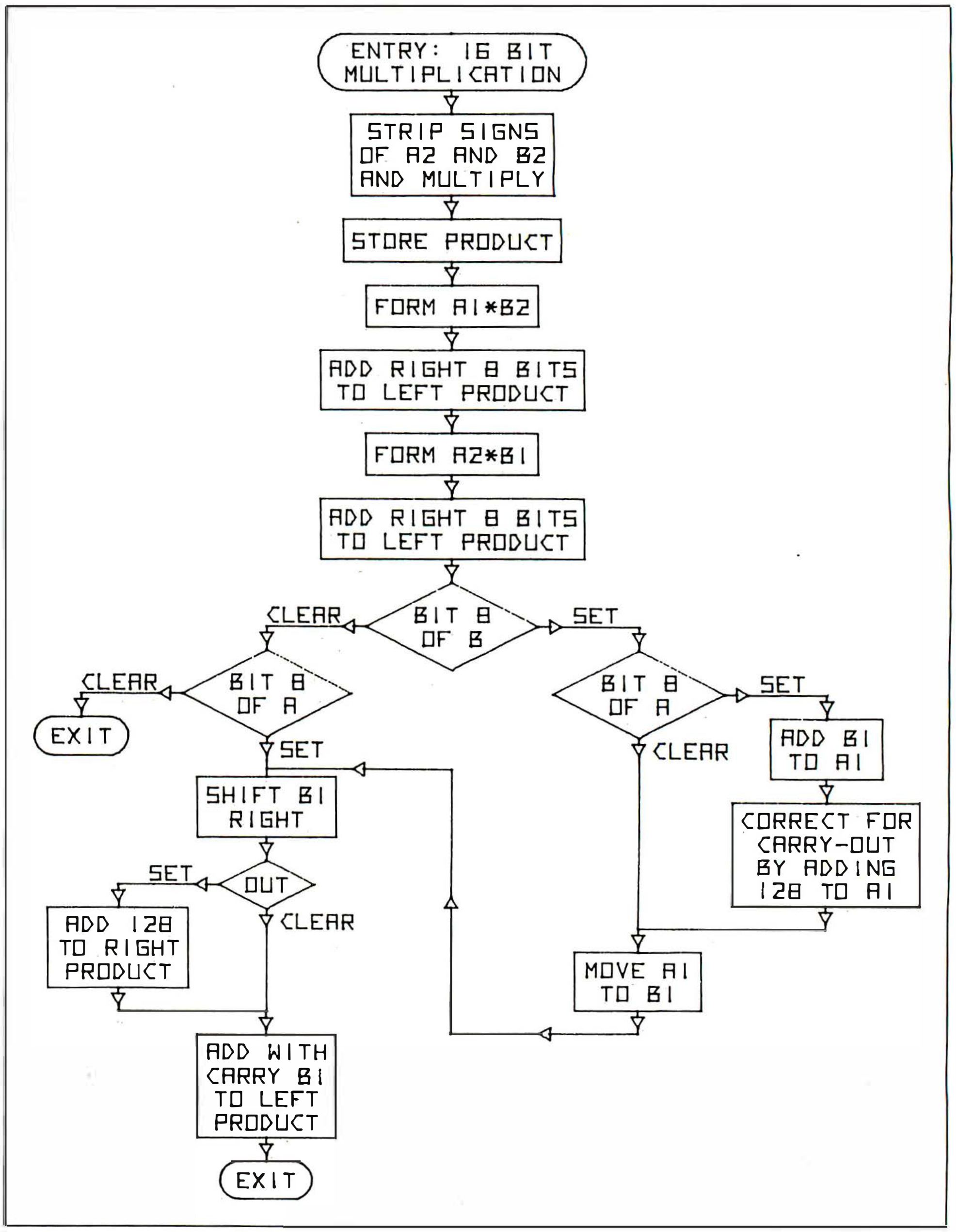


Figure 5: Alignment of the rightmost 16 bits of a product of two 16 bit integers, relative to two 8 bit words of memory. Note the overlap (*) of the $\alpha_8\beta_8$ term which appears twice. This overlap is also seen in figure 4, which was used to derive this partial product representation.

A Note about the Flowcharts. . .

The flowcharts labelled algorithm 1 to algorithm 4 in this article were supplied in camera ready form by the authors. They were produced at Texas A&M University using flowchart documentation packages and plotter outputs. They provide an excellent illustration of practical applications of computer technology in the field of illustration and drafting.



*Algorithm 2: A 16 bit signed two's complement multiplication, implemented with 8 bit by 8 bit signed two's complement operations (products A2*B2, A1*B2, A2*B1 as defined in text). This is coded in 6800 assembly language in listing 4, using the MPY-8AJ hardware.*

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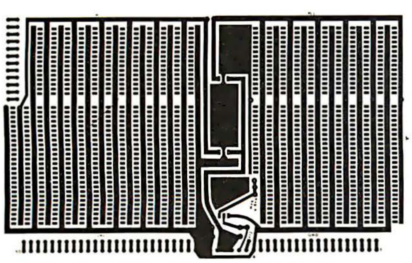
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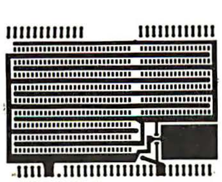
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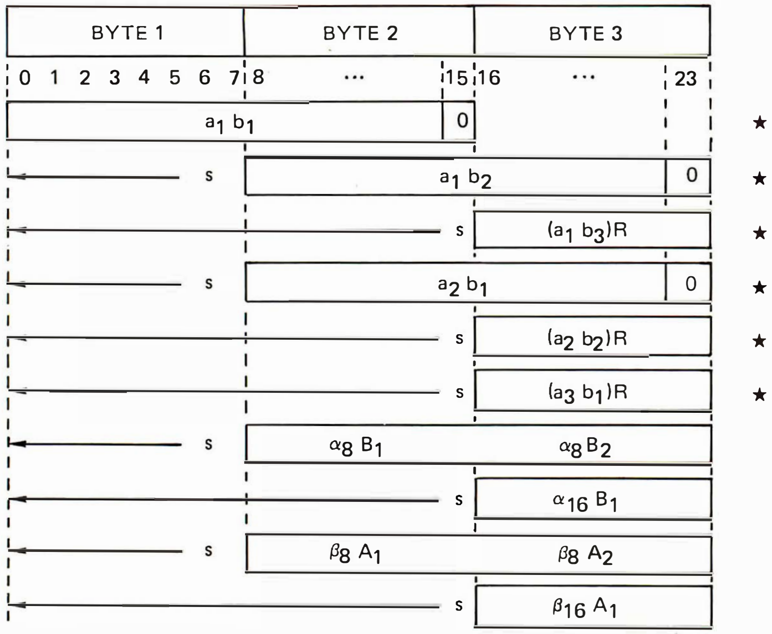
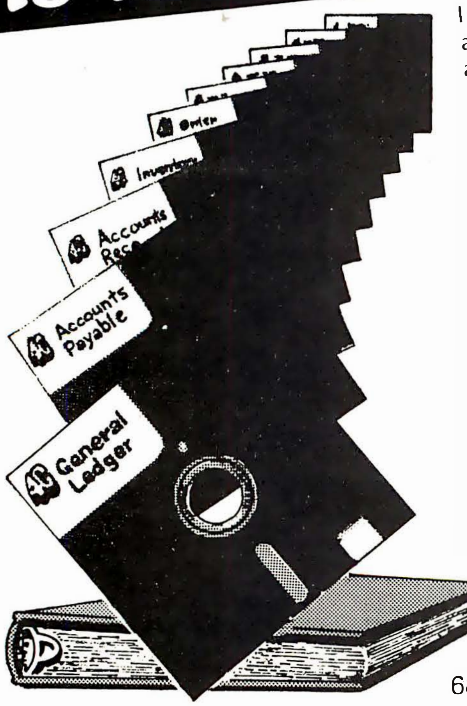


Figure 6: When performing floating point operations, a 24 bit mantissa is convenient. Here is shown a partial product breakdown, with components of the products designated as in figures 4 and 5. The hardware multiplier is used to form partial products marked with a star (★). The term R indicates partial products formed with the multiplier's rounding input active. This partial products sum assumes positive operands; the use of signed operands is accommodated by extending the sign bit (most significant bit) left as indicated by arrows. As in other illustrations of this article, bits are numbered from the most significant (0) to the least significant (23).

complement number $0\alpha_9 \ldots \alpha_{15}$, b_2 the number $0\beta_9 \ldots \beta_{15}$). Also, the lower triangle is the least significant eight bits of the product B_1A_2. In figure 5, the alignment of these partial sums is displayed relative to two 8 bit words which contain the product. (A little calculation shows that the product A_2B_2, as an 8 bit two's complement product, is of little use; only the rightmost eight bits will be correct. The wedge left over in the center would be the leftmost bits of $0\alpha_9 \ldots \alpha_{14} \times 0\beta_8 \ldots \beta_{14}$ were it not for carry from the right part of this product.)

While it is easy to change A_2 into a_2 (for example, if A_2 is in accumulator A, the instructions LSR A; ROL A do the trick in a mere four cycles), it seems a good thing for hardware to be doing. Recall our "port" is four bytes wide and we are only storing multiplicands in two of them. A third can be used for a "condition set." We might, for instance, use bit 5 to strip the sign from the contents of FM, bit 6 to strip the sign from SM (the first and second multiplicands). We use URP for the address of "condition set." Algorithm 2 shows one order in which the parts of figure 5 can be formed and added. Note that most of the additions do not require carry out.

The program in listing 4 is at least three times faster than usual 16 bit multiplication



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due to use of the hardware multiplier. (Motorola program PGM7, for instance, uses about 700 machine cycles.) No use is made of the stack or index register, and the numbers multiplied are left unchanged. (Many multiplication routines gobble the operands as they go.) Similar programs (with roughly the same gain in speed) can be written for integer multiplication of 3 or 4 byte length. Nothing new happens, however: our hardware multiplier still needs to return the product right justified in two bytes (with bit 0 off).

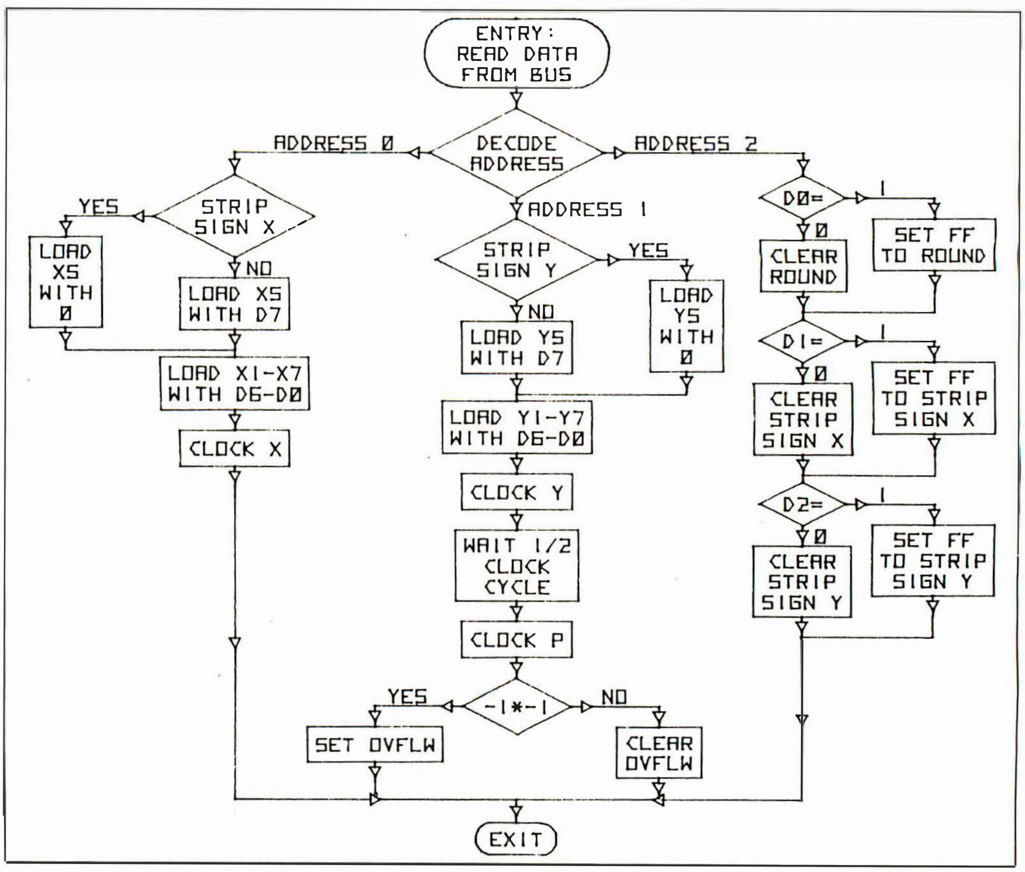
Well, we're in for a little surprise.

Number Crunching

Another application of our multiplier is to floating point multiplication. Floating point arithmetic allows us to keep track of numbers with a vastly larger range than fixed point arithmetic would in the same amount of storage. The reasons for adding floating point operations to a microsystem lie beyond the scope of this article, but we include this because something curious happens when an 8 bit two's complement multiplier is used in floating point multiplication.

The system we decided on for floating point representation allows a range of about $\pm (10^{-38}$ to $10^{37})$ (plus the number 0) and has an "accuracy" of about seven decimal digits. Byte 0 holds the exponent e, the power of 2 in two's complement form, and bytes 1 to 3 hold the two's complement normalized mantissa m. (*Normalized* means $-1/2 < m \leqslant -1$ or $1/2 \leqslant m < 1$.) The number represented is $m \times 2^e$.

This system was picked mainly for speed. Memory was also considered: greater accuracy uses more time and space to store user data. More complicated and lengthy routines to compute transcendental functions, for instance, are required. Since we were designing a floating point package from scratch, compatibility with established methods did not seem to matter much.



Algorithm 3: Hardware write cycle operations at the interface for the high speed multiplier. This algorithm shows the actions needed during a write cycle in which the computer sets up operands. Address 0 writes the X operand from the data bus, optionally stripping the sign bit. Writing to address 1 also performs the multiplication by clocking the product latches after a suitable wait period of one half the microprocessor's clock cycle. Writing to address 2 is used to set the state of three flip flops which control the multiplier's ROUND input, stripping of sign from X inputs and stripping of sign from the Y input. Default values which are initialized on power up, as well as a system reset, have all three control flags cleared.

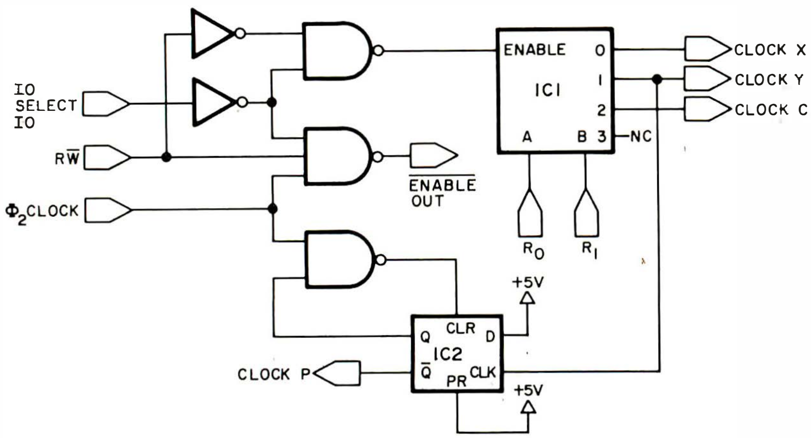


Figure 7: Clocking and input address decoding. IO select, RW, Φ_2 CLOCK and address R_0, R_1 are present on the SwTPC IO port bus. Signals CLOCK X, CLOCK Y, and CLOCK P go to the MPY-8AJ. CLOCK C is used to set condition code for sign stripping and rounding (see figure 8), and ENABLE OUT is used to enable three state output buffers (figure 9). IC1 is an MSI device, a 2 to 4 decoder (half of a 74LS139); IC2 is half a 7474, a positive edge triggered flip flop with preset and clear. Details of this circuit in relation to the entire high speed multiplier subsystem will be found in the complete schematic to be presented in part 2 of this article.

Let A and B be two floating point numbers in this representation. We consider the problem of calculating A X B. First of all, the exponent is no problem — just add — so we will forget that for now. Let the mantissa of A be A_1 A_2 A_3 (each A_i is a 1 byte word) and that of B be B_1 B_2 B_3. Suppose both A and B are positive (so that A_1 and B_1 are positive two's complement numbers).

Let the bits of A's mantissa be $\alpha_0\alpha_1 \ldots \alpha_{23}$ and those of B's be $\beta_0\beta_1 \ldots \beta_{23}$. We need also the unsigned parts of the bytes A_i and B_i obtained by setting the first bit zero; call these a_i and b_i. For example, A_2 is $\alpha_8\alpha_9 \ldots \alpha_{15}$ and a_2 is $0\alpha_9 \ldots \alpha_{15}$. We now think of each of the a_i and b_i as being a mantissa: thus

$$a_1 = \alpha_1/2 + \alpha_2/2^2 + \ldots + \alpha_7/2^7,$$

and they satisfy $0 \leqslant a_i < 1$, $0 \leqslant b_i < 1$.

With all this notation, the mantissa of A is

$$a_1 + \alpha_8 2^{-8} + a_2 2^{-8} + \alpha_{16} 2^{-16} + a_3 2^{-16}.$$

When we write out the product of this with B and align the parts (much like we did earlier), we find the products now need to be left justified. For example, a_1b_1 (which form the first few bits in the product) is 14 digits plus sign (which is zero), and the right shifted product is simply in the wrong place for adding into the product we are forming. (This is the little surprise: our hardware multiplier needs to return the product left shifted for floating point arithmetic.)

One way out is to have the multiplier return sign plus first seven bits in FM, next seven bits then 0 in SM: that way we don't have to waste time shifting. (This neatly uses all four bytes in the port, also.)

Figure 6 is the floating point analog of figure 5. In it we show how the parts of the product line up. (We forego the analog of figure 4, although one was pondered over to arrive at figure 5.)

One more thing: look at the products a_1b_3, a_2b_2 and a_3b_1. They're only the left eight bits, right? What if we could add 2^{-8} to the product: that would *round* (up, the right way since everything is positive), that is, cause a value of 1 to be added in if the part thrown away were more than 1/2 X 2^{-7}. The MPY-8AJ has precisely that input:

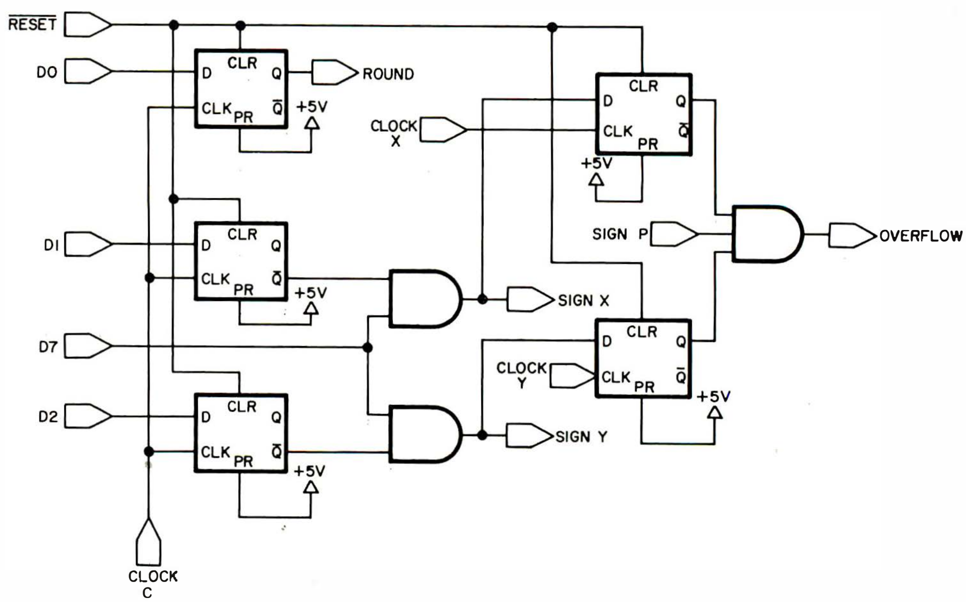


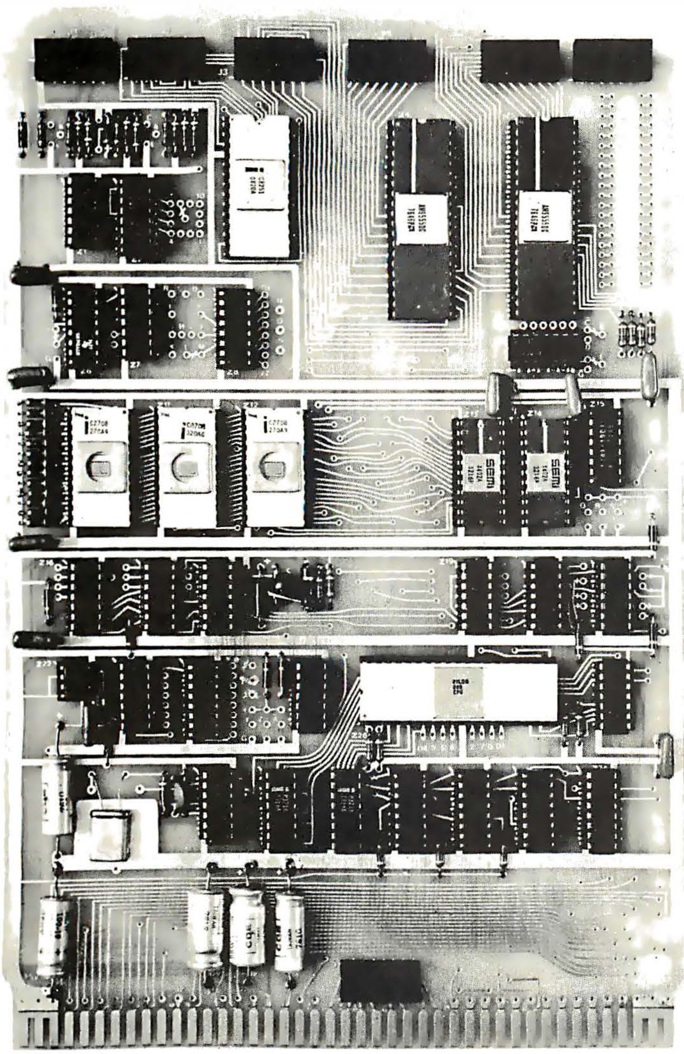
Figure 8: Sign stripping, rounding and overflow decoding. RESET, D7 and D0-D2 are SwTPC bus signals. Outputs ROUND, SIGN X and SIGN Y go to and signal SIGN P comes from the MPY-8AJ. CLOCK C, X and Y are generated by figure 7 circuitry. All flip flops are half of a 7474 as in figure 7.

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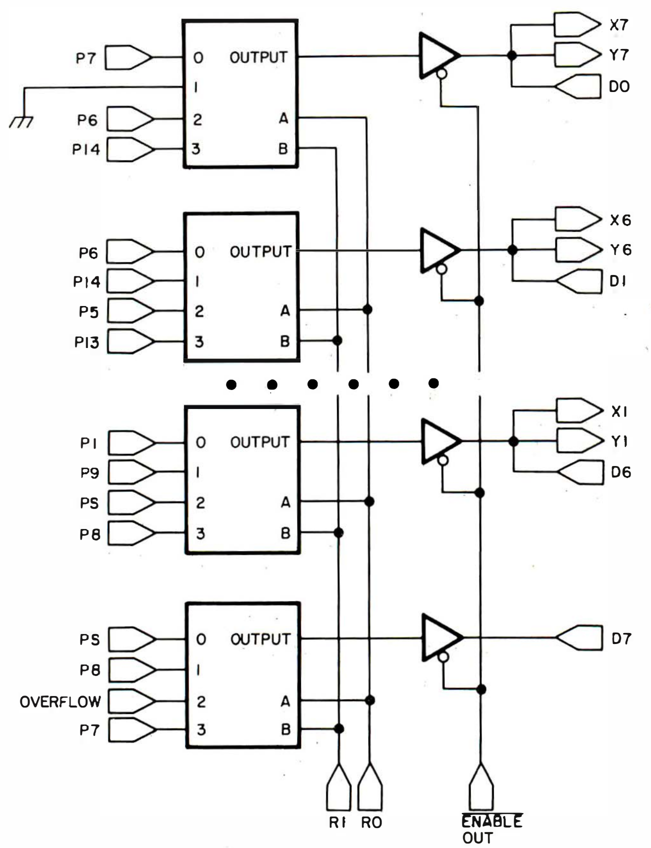


Figure 9: Output decoding. Four MSI devices, 74153 dual 4 to 1 data selectors, are used to decode outputs PS, P1, . . . ,P14 of the MPY-8AJ as well as the OVERFLOW signal generated (on the condition in figure 8). Two three state 74125 quad buffers decouple the low impedance totem pole 74153 outputs from data bus D0, D1, . . . ,D7. Since the X and Y inputs of the multiplier are high impedance, X1-X7 and Y1-Y7 are coupled directly to data bus bits D6 to D0. ENABLE OUT signal comes from figure 7.

we decided to use the "condition code" (already used to strip signs) to set the round condition. Bit 7 on sets round, off clear, any time data is stored in URP.

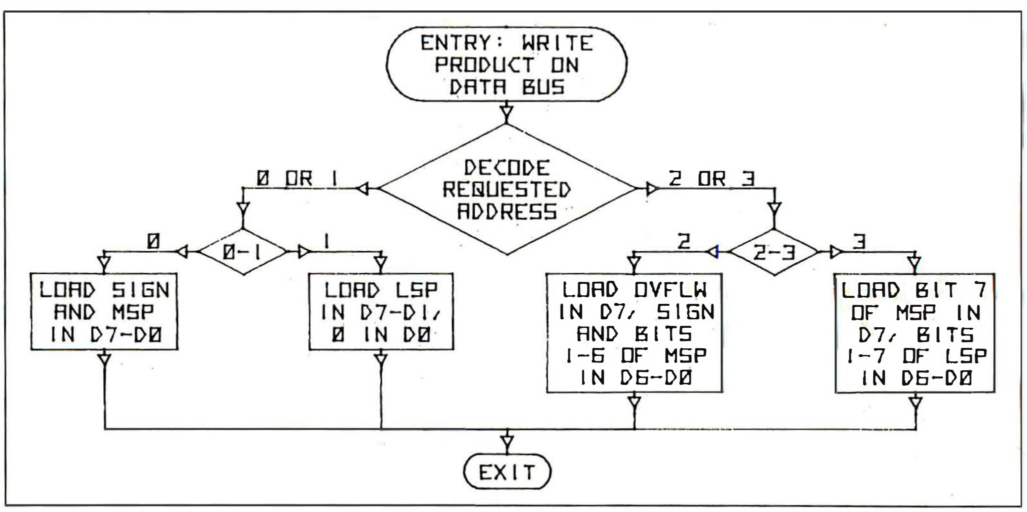
Logical Design of Hardware

Algorithm 3 shows what happens when data is stored in the port which contains the hardware multiplier. Address 0 is FM, 1 is SM and 2 is URP (where the condition code is set). Figure 7 shows logical design of input address decoding, clocking and output enable signals.

One condition not dwelled on earlier is the overflow condition of the product. Recall there is no 15 bit two's complement representation of –1 X –1; the MPY-8AJ returns –1 (as does its software equivalent MPY8S0 in listing 3). Note also that URP always has its first bit 0. Since some applications (not discussed here) need to check the overflow condition quickly, we turn this bit on on detecting –1 X –1. (Thus the test is simple: overflow if and only if URP is negative.) We show logic to strip signs, set the ROUND input (to MPY-8AJ) and detect overflow in figure 8.

Output decoding consists of performing the function shown in algorithm 4. Figure 9 shows our hardware solution using MSI 4 to 1 line data selectors and three state output buffers.

Next month's conclusion of this article contains detailed construction information for the SwTPC 6800 system. Also included is test software.■



*Algorithm 4: Hardware read cycle operations for the high speed multiplier provide two ways of looking at the 15 bit (sign plus 14 bit product) outputs of the multiplier. When addresses 0 and 1 are accessed, the 16 bit number in these two bytes represents a left aligned 15 bit two's complement product with a low order 0 bit and high order sign bit. When addresses 2 and 3 are accessed, the 16 bit number in these two bytes consists of a right aligned 15 bit product, with the most significant bit set by the overflow bit (see algorithm 3) which is 0 normally, set to 1 if a product of –1 * –1 is detected.*

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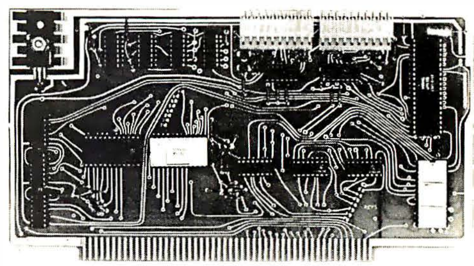
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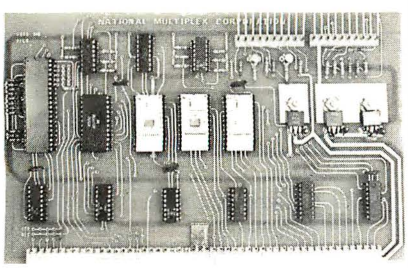
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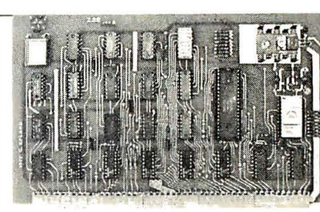
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____**Introduction to Biomedical Electronics,** by J Bukstein. $5.95

Cookbooks

____**Active Filter Cookbook,** by Don Lancaster. $14.95

____**TV Typewriter Cookbook,** by Don Lancaster. $9.95

____**TTL Cookbook,** by Don Lancaster. $8.95

____**CMOS Cookbook,** by Don Lancaster. $9.95

References

____**How to Buy and Use Mini and Microcomputers,** by William J Barden, Jr. $8.95

____**Payroll with Cost Accounting,** by Lon Poole. $12.50

____**Problems for Computer Solution,** by Steve Rogowski. $9.95

Tune In and Turn On!

Steve Ciarcia
POB 582
Glastonbury CT 06033

"Hi, Steve, you look lost in thought." Ken seated himself beside me on the front step of my house. "Your computer finally getting to you?"

I raised my head slightly and shook off the daydream appearance. "Oh, don't mind me. I'm just waiting for my neighbor Clarence to come over the way he usually does when he sees me sitting out here. No doubt he's going to tell me about the latest gadget he just bought or tantalize me with some new component in his kilowatt stereo system." The more I thought about Clarence's one-upmanship, the madder I became. "I go out and buy a lawn mower and he buys a tractor for his 1/4 acre lawn. I paint my trim and he paints his house."

"Don't get so upset. I've got a neighbor like that down at my end of the street, too. It's not that unusual." Ken's presence was beneficial. I was less likely to commit homicide with witnesses around. That kind of stuff was too messy anyway. I had something better planned for Clarence. In fact the more I thought about it the better I felt.

"Clarence doesn't have a computer yet, does he?", Ken asked.

"No. But I'm sure he's looking. The last time he was here he told me how he had found out about mine. Apparently someone showed him a copy of BYTE. He's looking for a computer now, I'm sure." Ken looked at me with a certain degree of skepticism. He also has a technical background and understands the uses and applications of computers.

"What would Clarence do with a computer?", he asked. I was sure he wanted to own one but resolved that he couldn't afford one in the foreseeable future. "He doesn't know the first thing about them."

"Knowing Clarence, he'd probably use it as a door stop. Use is unimportant to him. Ownership is the key. I really don't think I can keep him from buying one but I'm going to take advantage of the fact that Clarence always has to have something better." I had been scheming, devising and programming at a feverish pace ever since Clarence put me on notice that he was going to buy a computer.

"What are you planning?" Ken was becoming increasingly curious.

"Oh, nothing special. I'm just going to make Clarence think that my computer's capabilities are greater than they actually are. If he wants to buy one that does what I'm going to simulate, it'll cost him a hundred grand.

Ken smiled. He knows that deep down I am soft and gentle but also knows that I enjoy playing a practical joke.

"I know you have quite a system, but how are you going to make it appear like one costing $100 K?", he quizzed.

"Skulduggery and trickery, my friend." I was about to explain when Clarence suddenly appeared on my walk. I gave Ken a nudge and said, "Here he comes, right on time. Just play along."

"Hi, Steve, Ken. I just happened to notice you out here and thought I'd stop over for a chat. I've been giving that computer thing some thought. Dropped by the computer store today to ask them about... what did you call it. . .mass storage? Well anyway, they said I should get four dual density – I think it was – floppy disks. That should be adequate. You only have two, don't you, Steve? You must find yourself limited," Clarence continued. First it was the best 8 bit unit he could find; then he settled on a 16 bit system but was still trying to decide whether 64 K of memory would be adequate. "I looked at some printers, too. I think your DECwriter is adequate, but doesn't Digital Equipment sell something a little better? For more money, of course."

I was coming to a slow burn. Ken's expression seemed to say, "Is this guy for real?"

"I really don't know, Clarence. Why don't we go in and check with my computer."

Clarence's eyebrows rose a little as we got up to enter the house. I made a point of mentioning that he should check the mailbox beside the door since he was closest. As he opened it I said, "Never mind, I just remem-

Part 1: A Computerized Wireless AC Control System

In which a homebrew wireless AC control system foils Clarence's one-upmanship...

bered I gave the mail to the computer earlier today."

Clarence's mouth opened a bit, but he was not ready to argue the point. I gave Ken the elbow again to keep him from saying anything. "Just to be on the safe side, maybe I'd better check. Please close the door and come into the den."

As Clarence turned to close the door, I stepped into the den, reached behind the corner of one of the bookcases and pressed a button. This was the signal for the computer in the basement to go into action. I started counting silently down from 20. By the count of ten Clarence had entered the den. I motioned for Ken and Clarence to sit down and said, "We'll get the information you need later, Clarence. I'd better check on that mail first. It might be important." Six, five, four . . . . I stood up in the middle of the room and said, "Computer?" . . . Ken and Clarence looked at me as if I were crazy . . . two . . . one . . . zero . . . .

At the next instant the table lamp next

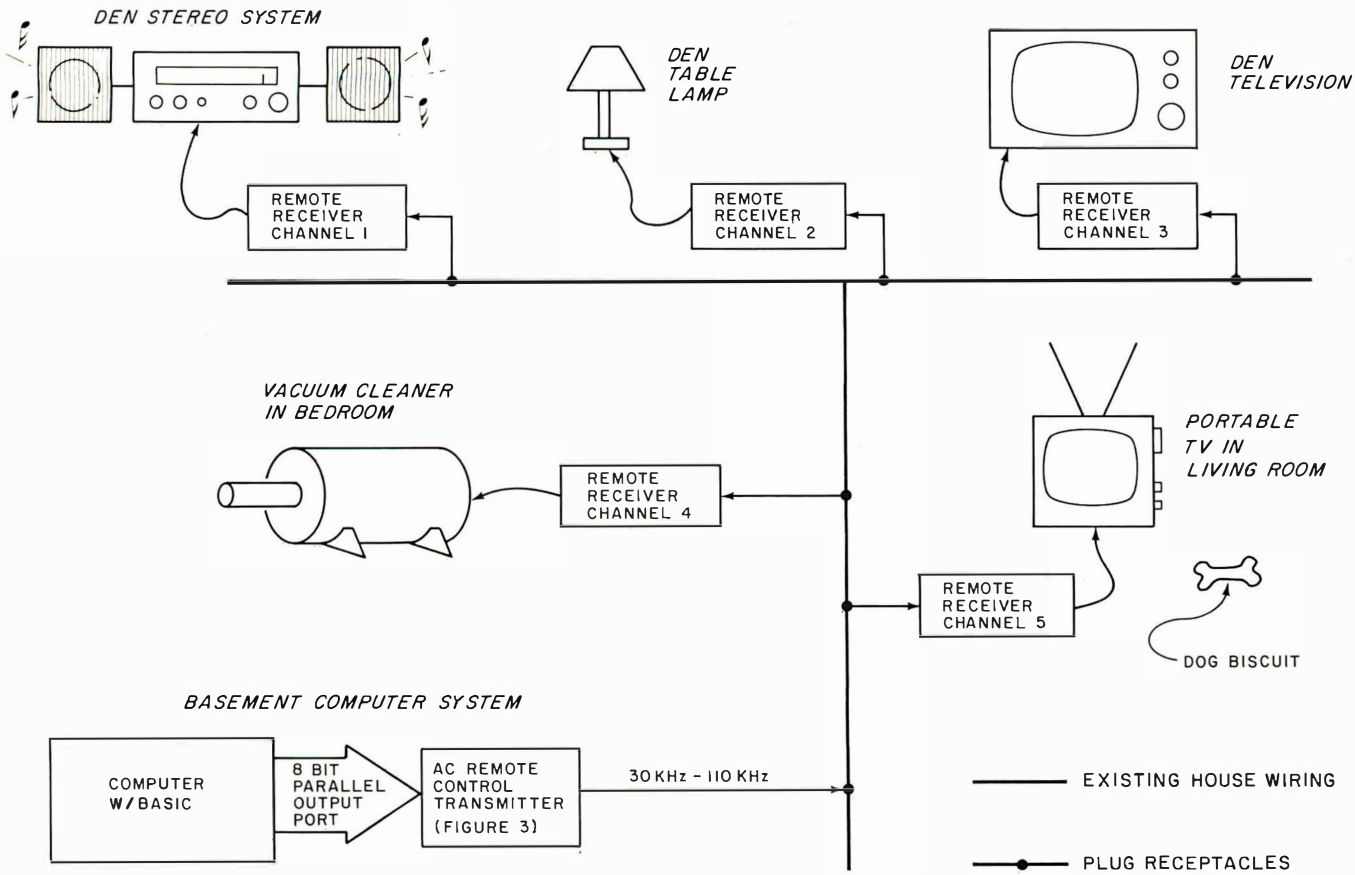


Figure 1: Block diagram of the author's wireless AC remote control system. An AC transmitter modulates the existing house wiring with high frequency signals. These signals are detected by special receivers (described next month) which plug into any AC receptacle. Appliances or other electrical devices can be plugged into the receivers and controlled by the user's home computer. The setup shown is one application of a 4 receiver system. Applications include turning house lights on and off during the user's absence, automatically taping off the air from a stereo, etc.

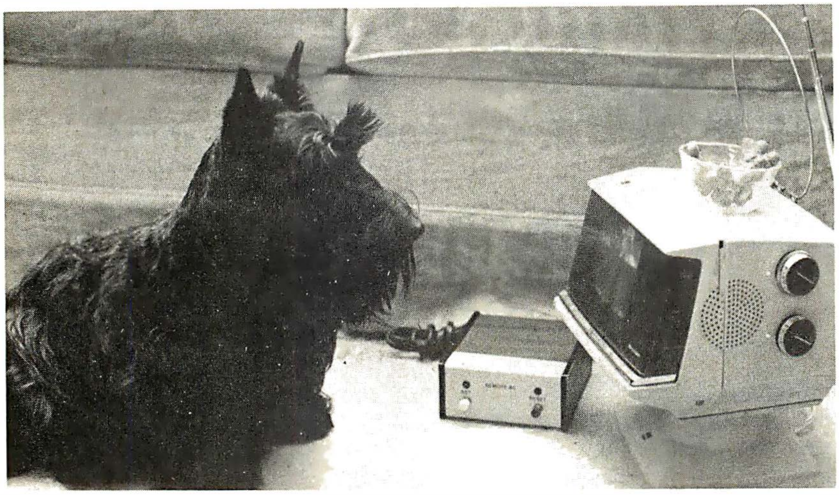


Photo 1: AC remote receiver (shown in center of photo) enables author's Scottish terrier, Brenda, to watch Lassie reruns.

to me seemed to turn on by itself. A second later the stereo turned on, though no music was heard. Presently, in a nonhuman voice that a Star Trek fan would appreciate, the speaker said, "Computer!" I started counting down mentally from 30 this time.

"WHAT!?", Clarence and Ken both said in unison. I put my forefinger to my lips and motioned to Ken to play along. Clarence was too engrossed in the current situation to notice. "How did you do that?", he said excitedly.

The 30 seconds were almost up as I stood and said, "Computer, did I give you the morning mail to process?" Two . . . one . . . zero . . . . The voice responded with the single word, "Affirmative."

I started to count ten seconds this time.

Clarence's eyes were wide open as I said, "Computer, give me a listing of the mail delivery."

"Mail Delivery Recorded ... Date 3-20-78 ... File N472 ... Magazine – Popular Science ... March 1978 ... Bill – Home Heating Inc ... $64.32 ... Due 30 days ... Bill . . . ." The somewhat metallic voice spoke in a monotone and at a constant rate. It was unmistakably synthetic and no one could dispute it. I listened to the computer speaking through the stereo system and waited for the key word (my next cue). ". . . Daily Newspaper . . . Hartford Courant . . . 3-20-78 . . . Major headlines as follows . . . .

"Enough!", I shouted, and the voice stopped. It was actually programmed to stop anyway, and I started mentally counting to the next phase.

"What kind of computer is this? How big a system do you have?", Clarence exclaimed. I waved him back to his seat and decided to lay it on a little thicker.

At the right time I said, "Computer, have you finished the house work?"

"Negative ... Master Bedroom should be vacuumed . . . it shall be done . . . ."

A vacuum cleaner switched on upstairs and could be clearly heard in the den. Clarence jerked his head around when he heard the noise and nearly fell out of his chair. I turned toward the stereo and said, "No! Do it later!" Within a couple of seconds the noise of the vacuum cleaner stopped. This told me I had about two minutes.

Clarence and Ken were amazed. "Well Clarence, what do you think? The house is completely under computer control. It knows what I'm saying and does what I want."

"Will it respond to my voice?", Clarence asked weakly.

"Oh I'm sure it understands you, but it only responds to my voice ... obviously for security reasons. We wouldn't want someone telling it to do something bad, would we? I only use it for constructive purposes, like my checking account." The two minutes were up. I raised my arm and pointed to the TV set. It switched on apparently by itself.

A few seconds later a checking account statement appeared on the screen and started scrolling slowly up the screen. Clarence got up, walked over to the display and stared at it as though hypnotized. I grinned sadistically at Ken. He grabbed my arm and whispered, "How are you doing all this?"

"Shhh. It's done in BASIC. I have one of those new Votrax speech synthesizers feeding into the auxiliary input of the stereo. The TV is really a video monitor. It's wired to the computer system in the basement. Turning things on and off is simple with my new AC remote control receivers spread around the house. I just used the speak command in Zapple BASIC the same way other people use print commands. When the program is triggered, it starts a preprogrammed sequence. I know what it's going to say and how much time there is between statements."

"Oh, you're a nasty one, aren't you?" Ken smiled.

"So much for all this, Clarence; you must have better things to do. I have to go out soon. I hope you don't mind?" I glanced at my watch noticing it was nearing 7 PM, and motioned for him to follow me toward the front door. As we were leaving the den, the video monitor, stereo and lights extinguished as miraculously as they had come on. Clarence just shook his head and followed, muttering something about needing a drink.

At exactly 7 PM as Clarence was about to leave, we passed through the living room

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where he noticed a small TV sitting on the floor next to the couch. He was about to ask something when a bell sounded; my Scottish terrier Brenda came tearing into the room and sat in front of the TV. The TV came on instantly and a program flashed onto the screen. I waved my hand to Clarence and said, "Oh, don't worry about that. It's just a rerun of Lassie. The computer takes care of the dogs, too."

This last bit was obviously too much for Clarence. He just kept muttering as he left, saying something about maybe reconsidering his 16 bit decision and going to 32 bits. I never heard the rest as he left, still shaking his head.

Ken waited until Clarence was gone and then said, "I can understand how you staged the stuff in the den, but your dog?"

"Look Ken, if you're going to do something, you might as well do it right. As far as Brenda is concerned, she just heard a bell and came to sit and wait for a dog biscuit the same way she's been doing every night at 7 PM for weeks."

AC Remote Control

I don't expect everyone to build remote control devices like the ones presented here just to get back at the Clarences of the world, but I do see them as the next logical extension of the house computer system. Many experimenters have graduated from using the computer strictly for games and are now writing more sophisticated programs. They may be accounting, music, composition or straight number cruncher programs, but the key is evolution. The concept of a home management system is fine, but it is bound by the system peripherals.

The basic logic flow of any computer system is: input, process, output. The computer accepts data input, processes it based upon a fixed routine called a program, and outputs the results. This result can either be an alphanumeric response on a video display that allows the operator access to this processed information, or a logical result such as yes and no, or on and off. In the latter case, the single logical on or off value can also be used to control some device. A typical example is a furnace circulator pump. Temperature information is entered into the computer, which decides whether the heat is too high, in which case the pump should be off, or too low, in which case the pump should be on. This decision could be displayed at an operator console, instructing the operator to physically turn the pump on or off, but it would be far more efficient if the computer could perform the action as well as calculate the decision.

The concept of computer control is as old as the computer itself. Process control and data acquisition are the major applications of industrial computers. While the computer structure might be similar, the logistics are quite different. When a factory wants to add a computer to control a process, they automatically add 30 percent to the control costs for wiring! In the home application, even though the wiring cost might be less, the idea of stringing wires all over the house is abhorrent to most of us. No one wants to start punching holes in the walls.

The easiest alternative is wireless control. Such an approach uses the existing 115 VAC house wiring for both control power and signal transmission. This method is most cost effective in limited applications using fewer than a dozen channels, or in the case where the operations being controlled are not critical.

Carrier Current Systems

Simply stated, the carrier current method transmits a high frequency carrier (30 kHz to 500 kHz) similar to a standard radio transmission into the house wiring. It is superimposed on the 60 Hz, 120 VAC line and is broadcast throughout the house. This transmitted carrier, often referred to as carrier current, can be modulated to send music or digital information. In limited on and off control applications, though, the mere presence or absence of the carrier frequency is used to provide the control logic. The use of a modulated or unmodulated system depends ultimately on the number of parameters to be transmitted. If only one output is to be controlled, and it is going to be on or off (such as a desk lamp), a single frequency can be used. Detection of the frequency of transmission at the receiver turns the light on, and its absence turns the light off. Controlling two outputs requires two separate frequencies, one for each channel, and additional logic must be added in the receiver if the appearance of simultaneous output control is required. In cases where more than 20 channels are to be controlled or multiple settings are required at each controlled point, modulated transmissions are best employed. An example of this would be a 256 position level switch in some remote location. Rather than attempting to use 256 separate frequencies, a single frequency can be modulated and used to transmit an 8 bit code to the receiver. This is similar in format to the serial data presently used on cassette interfaces. The only difference is that the serial data stream is transmitted on a high frequency carrier

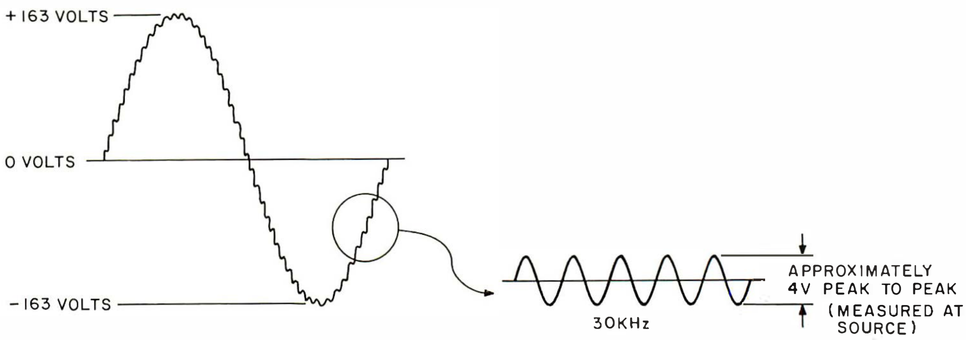


Figure 2: Example of carrier current transmission. The standard 60 Hz 115 VAC sine wave is shown being modulated by a 30 kHz carrier. Two different frequencies 4 kHz apart are used to turn devices on and off, respectively, in this design. (Note: drawing is not to scale.)

and detected in a receiver before being converted for use. This method should only be considered for extensive communications, since it is relatively expensive and the receivers are more complex.

The major consideration one should make when looking at a carrier current control system is the ultimate number of discrete points to be controlled. An output channel is defined as a single bit, ie: a 4 channel system would consist of four on/off control elements. In a single channel system, the simplest carrier/no carrier method is normally employed. For systems with the capability of two to ten channels, multiple frequencies with latching logic are usually considered. In cases where the minimum number of channels is 16, modulated carriers and serial data transmission are advised. There exists a gray area between ten channels and 20 channels. Both multiple frequency and serial data can be used in this range, but the cost difference must be considered.

Carrier Current Control Methods

There are four carrier current transmission methods that could be used on the standard home computer system:

1. Single Channel On/Off. Usually a high frequency carrier is transmitted through the house wiring. A tuned receiver turns on when the tone is transmitted, off when not.

> Advantages: Cheap. Less than $10 for both transmitter and receiver.

> Disadvantages: One channel only. Tone transmitter must remain on for output to remain on.

2. Multiple Channel — Multiple Frequency. Generally speaking, two high frequency carrier current signals are usually not transmitted simultaneously if they are from separate channels. The AC line is quite noisy and not exactly the best antenna. To avoid harmonics which could trigger unaddressed channels, single unique frequencies are used for each channel. In a multiple channel arrangement, no single channel is continually addressed, so some method must be incorporated to latch the logic output. The multichannel methods seen most often utilize pulsed transmission. A particular receiver's frequency is pulsed once or twice within a timed window. One pulse means "on," two mean "off." The desired control output is latched into a flip flop in the receiver.

> Advantages: Relatively inexpensive. About 20 different channels can be accommodated with a transmission bandwidth of 100 kHz. Only a single frequency receiver is required for each channel.

> Disadvantages: Pulsing the latch on or off requires external gating logic in addition to a tuned receiver. Multiple channel arrangements require considerable interchannel decoupling and narrow receiver bandwidths. Depending on the particular logic design, this can be inconsistent with "pulse window" techniques. Control pulses must be accurately timed using either hardware or software techniques. This method, while conceptually simple, requires considerable additional circuitry to make it glitch proof.

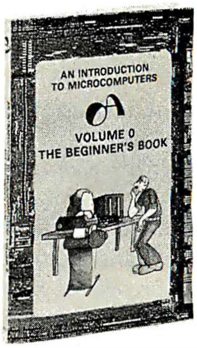
3. Multichannel — Multifrequency — Dual Receivers. This method is essentially the same as the previous one except that separate frequencies are used to turn the controlled output on and off. Either method would utilize the same transmitter.

> Advantages: Since separate frequencies are used for the set and reset functions, special constraints on timing are eliminated. Long time-constant input filtering techniques can be used to reduce glitches. No special software is necessary to drive the transmission device. This method combines the best features of methods 1 and 2.

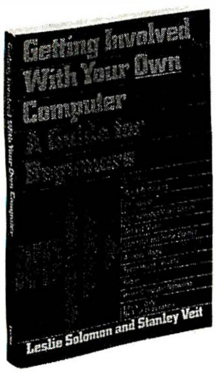
> Disadvantages: Decreases the total

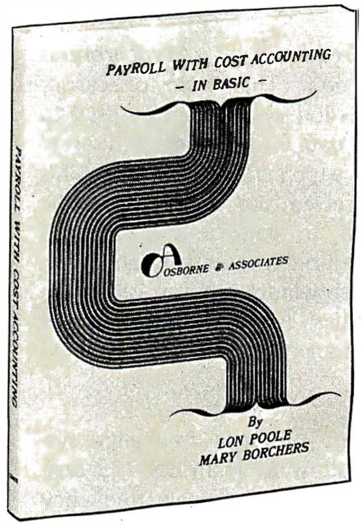
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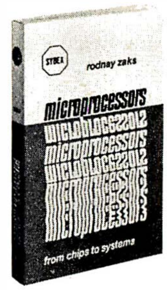
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Table 1: Power wiring table for figures 3a and 3b.

Number	Type	+5 V pin	−12 V pin	gnd pin	+12 V pin
IC1	MC1408	13	3	2	–
IC2	LM301A	–	4	–	7
IC3	MC4024	14	–	7	–
IC4	H11A1	no supply pins designated			
IC5	MC1403	1	–	3	–
IC6	741	–	4	–	7

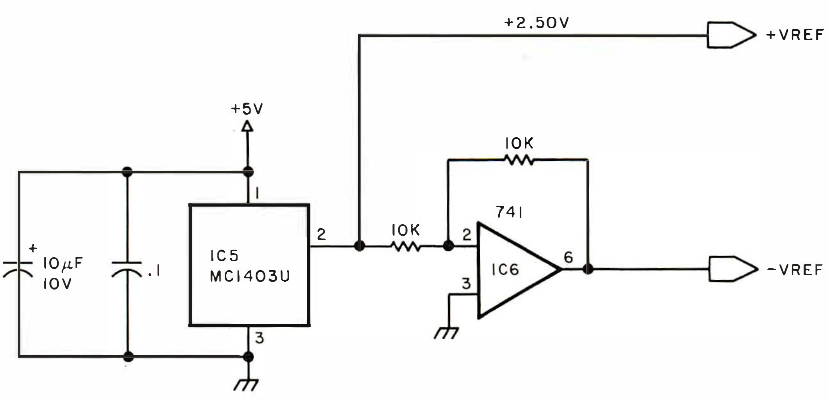
number of possible control outputs. Since two separate frequencies are required for each channel, only about ten total channels can fit in a 100 kHz bandwidth.

4. Single Frequency – Asynchronous Data Transmission. This type of carrier current transmission system can be used to transmit serial data rather than a discrete control signal which is on or off. This data, when received and decoded, can be effectively used to control a number of devices. The method is essentially an extension of the pulse window transmission concept stated earlier. Finer filtering methods are required though, since timing is more critical.

Advantages: A single frequency system can allow as many as 128 controlled outputs on a single frequency for each 8 bit data word.

Disadvantages: Expensive. Transmitter is serial and each receiver must incorporate logic for serial to parallel conversion, usually in the form of a universal asynchronous receiver-transmitter (UART) or its equivalent.

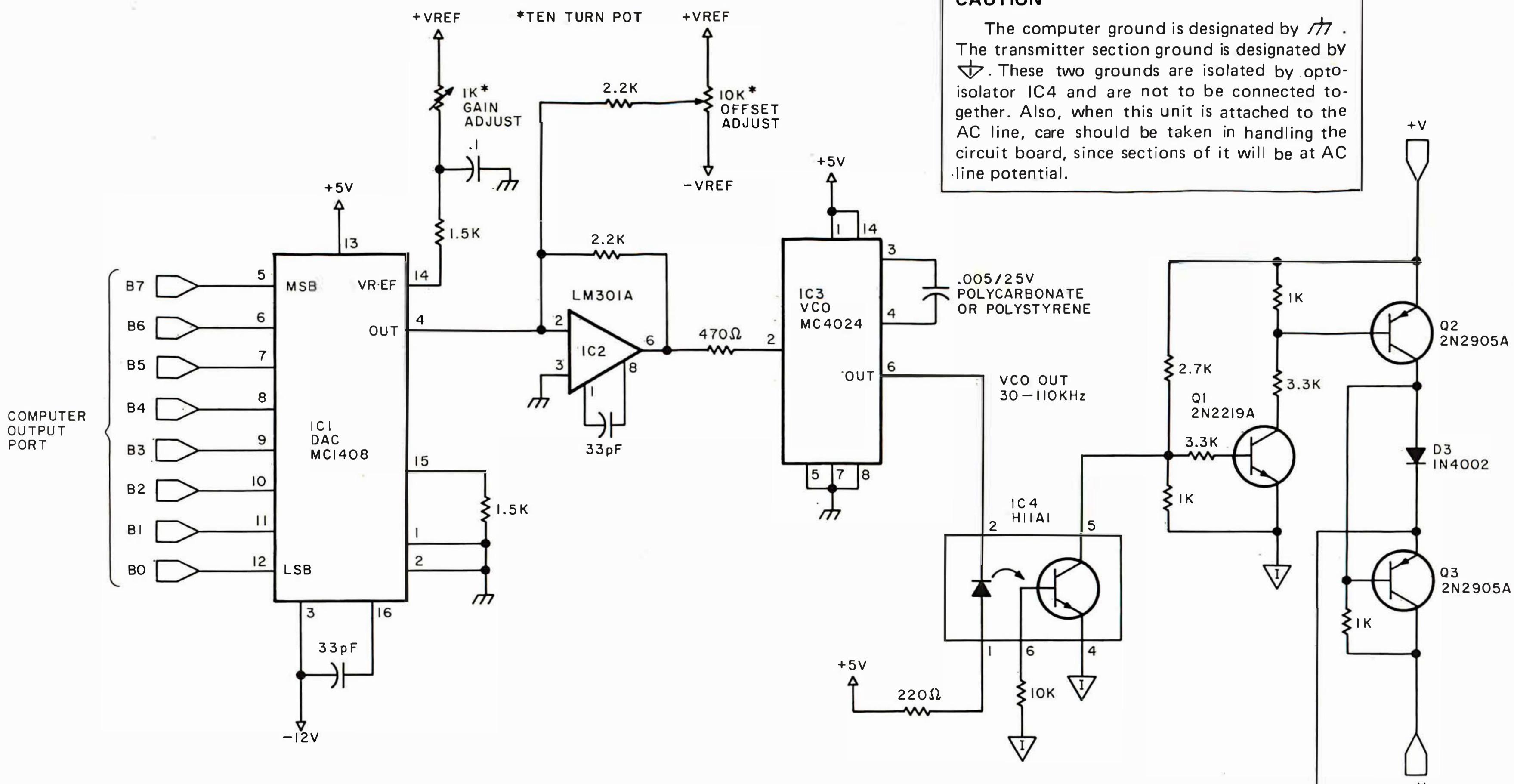
Figure 3a: Precision ± 2.50 V source for use with the transmitter in figure 3b.



A Design with Expansion in Mind

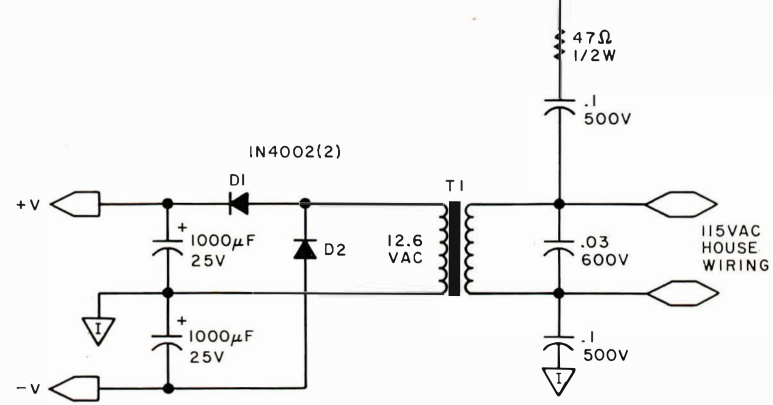
Most likely, any experimenter interested in constructing a carrier current control system will want to start with one or two channels. In my own case I can see expansion to maybe eight channels. The most cost effective approach for me is to use either system 2 or 3 described above. The multifrequency pulse transmission method has in my experience proven to be too unreliable in practice. Reliability is gained at the expense of considerable extra circuitry. In a system used to control the operation of 115 VAC appliances and lights when I'm not at home, I need as much reliability as I can get. For this reason my design relies on the use of two frequencies for each channel: one to turn the device on and a different frequency to turn it off. These frequencies will be grouped in pairs and referred to as a single channel. The bandwidth of each channel is about 8 kHz. In practical terms this means that, if the transmitter has a total frequency range of 30 kHz to 110 kHz, or 80 kHz, then 80 kHz divided by 8 kHz equals ten independent channels. Within this 8 kHz band, two separate frequencies are allocated. One turns the device on while the other turns it off. In the example illustrated in this article, channel 1 occupies 35 kHz to 43 kHz. The on and off frequencies are 35 and 39 kHz, respectively. The next channel, channel 2, occupies 43 to 51 kHz and the on and off frequencies are 43 and 47 kHz, respectively. There is no magic strategy for picking frequencies. Each remote receiver detects two frequencies 4 kHz apart. The only consideration is that all receiver frequencies be separated by at least 4 kHz. The fewer the channels, the further apart these frequencies can be. In a 2 channel system, choosing widely separated frequencies is safest.

Figure 3b: AC remote control transmitter. The circuit consists of a digitally programmable frequency generator (IC1, IC2, IC3, IC5 and IC6). The output of IC1, a digital to analog converter, is converted from a current to a voltage by IC2 and sent to IC3, a voltage controlled oscillator. In this design, the voltage controlled oscillator can produce frequencies in the 30 kHz range. Opto-isolator IC4 keeps the computer circuitry from interacting with the house wiring (see CAUTION note!). The transmitter section consists of IC4, Q1, Q2, and Q3. The three transistors form a power amplifier which couples the signals through a capacitor onto the AC line. The .5 W output of the amplifier is sufficient to reach all areas of most home wiring systems.



CAUTION

The computer ground is designated by ⏚. The transmitter section ground is designated by ⏚. These two grounds are isolated by opto-isolator IC4 and are not to be connected together. Also, when this unit is attached to the AC line, care should be taken in handling the circuit board, since sections of it will be at AC line potential.



T1 12.6 VAC 300 mA filament transformer

IC5 2 to 2.5 V reference chip, MC1403u or equivalent.

All resistors are ¼ W 5% unless otherwise noted.

All capacitors are 100 V ceramic unless otherwise noted.

Transmitter Calibration

1. +VREF and −VREF should be + and − 2.50 ± 0.05 V respectively.
2. With a binary input of 00000000 to the digital to analog converter, adjust the offset adjustment pot to give an output voltage of 2.000 V on IC2, pin 6.
3. With a binary input of 11111111 to the digital to analog converter, adjust the gain adjustment pot to give an output voltage of 5.000 V on IC2, pin 6.
4. +V and −V should be approximately 11 to 13 V.
5. The output frequency at pin 6 of IC3 should range from approximately 30 kHz to 110 kHz.

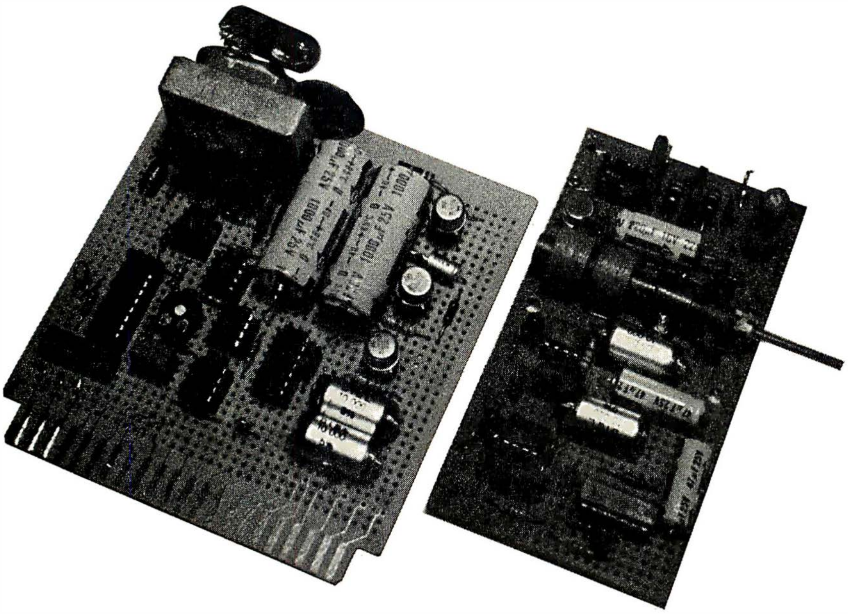


Photo 2: Prototype boards of transmitter (at left) and one receiver board. Receiver unit is described next month.

Channel 1 could occupy 35 kHz to 43 kHz, and channel 2 could be between 83 kHz and 91 kHz (and transmit on 83 kHz and 87 kHz). Apportioning bandwidth to maximize the number of channels is a major consideration in a multifrequency system. (I will describe the receiver section next month.)

Figure 3 is the schematic of the AC remote transmitter. It consists of a digitally programmable frequency source and an optically isolated house wiring driver.

The programmable frequency generator, IC1, IC2, IC3, IC5 and IC6, forms a precision voltage controlled oscillator. IC1 is an 8 bit digital to analog converter (explained in greater detail in my article "Control the World," September 1977 BYTE, page 30) whose output current is proportional to the 8 bit data word impressed on its input lines. The current output is converted to a voltage through IC2 and presented to the input of IC3, voltage controlled oscillator (VCO). Its output frequency is proportional to input voltage.

Analog frequency sources such as this are usually avoided because of stability problems. The alternative involves programmable divided-by-N counters and a crystal frequency input, which would mean about 25 integrated circuits to produce the same range of selected frequencies. Therefore, it is important to overcome potential stability problems. The major error-producing components in such designs are usually the voltage references and oscillator timing elements. By using a precision voltage reference circuit, IC5 and IC6, and incorporating polystyrene low drift capacitors in the voltage controlled oscillator section, these problems are virtually eliminated.

The result is a digitally programmable oscillator. With the values chosen, the range is about 30 kHz to 110 kHz. Changing the output frequency is simply a matter of changing the code on the digital to analog converter. Within the 80 kHz range of the voltage controlled oscillator there will be 256 discrete increments of frequency. Presuming that the input and output characteristics are linear, each increment would be 80000/256 or approximately 300 Hz. This means that, if a digital input code of binary 0000000 produces an output of 30,000 Hz, then octal 00000001 would be 30,300 Hz. Further extrapolation gives an output frequency of 49.2 kHz for binary 01000000 (decimal 64). In reality, the voltage controlled oscillator is not perfectly linear, but the output frequency can be set empirically by using a simple BASIC program. This setup procedure will be covered in detail when I discuss the receiver calibration section next month.

Once the oscillation frequency has been produced, the next problem is to transmit it through the house wiring. This transmitter section consists of IC4, Q1, Q2 and Q3. The oscillator output is optically isolated and coupled to the output driver stage through IC4. The three transistors form a power amplifier and pump about .5 watts onto the AC line. This amount of power is sufficient to reach all areas of your home and probably a few of your neighbors, but there should be no interference with any household appliances. [*As in all carrier current systems, the range is any AC wiring sharing the same final step down transformer. This might be two or three houses in suburbia, or one floor of an apartment house or dormitory . . .* CH] Since the output driver is isolated from the computer, it cannot use the computer power supply as its power source, so components D1, D2 and T1 form a voltage doubler circuit

```
100 FOR X = 0 to 255
110 OUT 2,X
120 REM PORT 2 IS THE OUTPUT PORT ATTACHED
        TO THE DAC INPUT
130 FOR D = 1 TO 500
140 NEXT D
150 REM THIS IS A DELAY ROUTINE SO THAT THE PROGRAM
        DOESN'T SCAN TOO FAST TO SEE
160 NEXT X
170 GOTO 100
180 REM CONTINUE TO CYCLE INDEFINITELY
```

Listing 1: A BASIC program to test the voltage controlled oscillator shown in figure 3. The program causes the output frequency of the oscillator to ramp up in fairly linear fashion and reset.

to provide approximately + and − 13 V to run the driver. It is important to note that there are two separate grounds in the circuit. One is the computer ground and the other is the driver circuit ground. They are NOT to be connected together (see CAUTION note).

Building and Testing the Transmitter

Photo 2 shows the transmitter on the left and one of the receiver boards on the right. It is necessary to build the receiver to completely test the transmitter without the use of an oscilloscope to make sure everything is all right. Certain shortcut methods can be employed this month, though, to give you reasonable confidence about the circuit's operability.

Build the circuit as shown in figure 3 with the exception of the driver circuit and IC4. Add a 0.1 μF capacitor in parallel with the 0.005 μF capacitor already between pins 3 and 4 on IC3. This will effectively lower the output frequency range of the voltage controlled oscillator into the audio range. By putting a 100 Ω resistor between IC3 pin 6 and an earphone whose other terminal is connected to ground, this audio tone can be heard. It is a simple matter to change the tone. The astute experimenter will realize that we have constructed a programmable tone generator, possibly suitable for music applications.

Use BASIC to Run the Controller

As with most of my recent designs, this one is driven by a latched parallel output port, and update speed is of no particular importance. This makes it a natural for BASIC, which sets 8 bit output ports. This interface controller can be set to any frequency within its range under program control. BASIC can also perform a simple test to determine whether the voltage controlled oscillator works (see listing 1). This program causes the output frequency of the voltage controlled oscillator to ramp up in a roughly linear fashion and reset. With the capacitor values in the schematic, the range should be approximately 30 kHz to 110 kHz. Again, picking any larger capacitor value will allow this sawtooth tone generator to be heard in the audio range.

Actual control of a device comes after the receiver section has been built and mounted in an enclosure such as that shown in photo 3. While it is difficult to discuss the application without having discussed the method, I don't want to leave everyone hanging till next month. The simple program in listing 2 controls two remote channels, designated channel 1 and channel 2, from the computer keyboard. This is written in Micro Com Zapple BASIC.

Next month I'll describe the design and construction of the receiver section as well as discuss more detailed applications. A natural for this project is to use a quantity of these remote receivers to control light and sound sources around the house to simulate occupancy when no one is home.

If you have any questions about this article or previous articles, please feel free to write to me. Please enclose a stamped, self-addressed envelope and I will attempt to personally answer all letters.

Next month: "Tune In and Turn On: Part 2."■

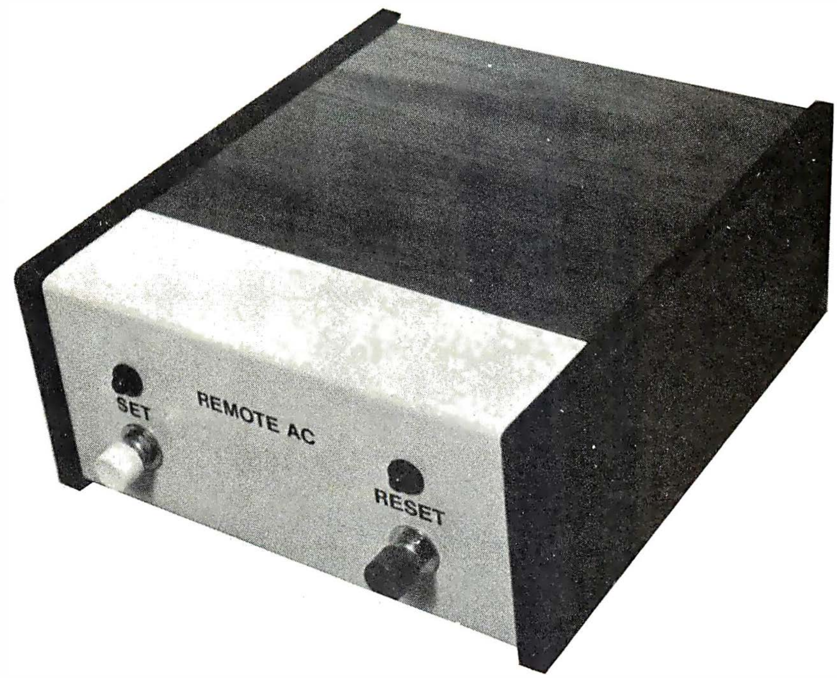
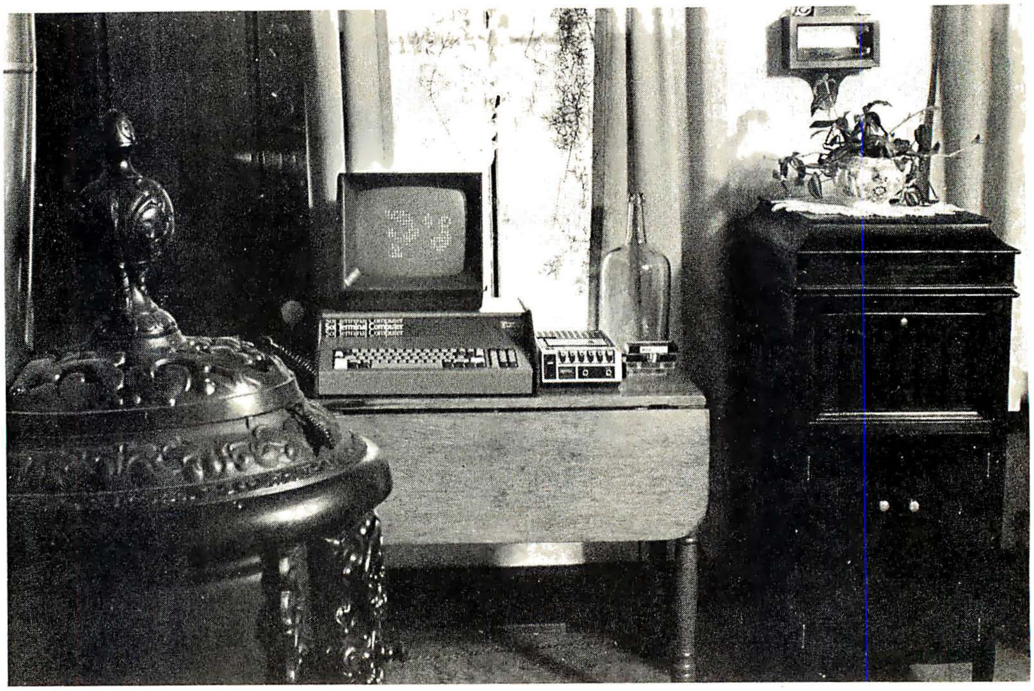


Photo 3: Complete receiver package. Remote controlled appliance plugs into rear of box. Set and reset buttons allow appliance to be controlled locally as well as remotely.

Listing 2: A sample BASIC program used to control the circuit in figure 3.

```
100 PRINT "INDICATE CHANNEL TO BE CONTROLLED
        -1 OR 2 -"
110 INPUT A
120 IF A ≤ 2 GOTO 150
130 GOTO 100
150 PRINT "DO YOU WANT TO TURN CHANNEL"; A; "ON OR OFF?"
160 INPUT B$
170 IF B$ = "ON" GOTO 300
180 REM THE REMOTE CONTROLLER IS ATTACHED TO OUTPUT PORT 2
190 REM THIS ROUTINE TURNS A CHANNEL OFF
200 IF A = 1 THEN OUT 2, 180
210 REM 180 IS THE DECIMAL OFF CODE FOR THE CHANNEL 1
        PROTOTYPE
220 IF A = 2 THEN OUT 2, 118
230 REM 118 IS THE DECIMAL OFF CODE FOR THE CHANNEL 2
        PROTOTYPE
240 GOTO 100
300 REM THIS ROUTINE TURNS A CHANNEL ON
310 IF A = 1 THEN OUT 2,162
320 REM 162 IS THE DECIMAL ON CODE FOR CHANNEL 1
        PROTOTYPE
330 IF A = 2 THEN OUT 2, 96
340 REM 96 IS THE DECIMAL ON CODE FOR CHANNEL 2
        PROTOTYPE
350 GOTO 100
```



The SOL-20 in a New England parlor context, obviously enjoying life. The entire system fits on one table with a video monitor on top of the computer and an audio tape recorder for mass storage to the right.

User's Report: The SOL-20

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Nashua NH 03060

John Kemmeny in his book, *Man and the Computer,* reveals his thoughts concerning the future of computers. Kemmeny believes that people will have access to large regional computers in the future. This will allow people to do many jobs in the home and provide entertainment and knowledge. A computer terminal in the home will be tied to a large regional supercomputer giving people the ability to do many things at home not now possible, such as reading the latest news stories, studying subjects for degree credit, storing recipes to allow the input of a week's menu and production of a grocery list of needed items, and the recording and computation of family financial matters. The possible uses of this type of computer are unlimited.

Processor Technology has taken this concept of the home computer terminal attached to a supercomputer one step toward reality by providing the home user with a terminal and microprocessor combination, the SOL, capable of functioning with, or independent from, another computer. The operating systems provided by Processor Technology allow the SOL system to operate as a microprocessor independent of any outside processor with its own peripherals until the terminal command is issued, which causes SOL to operate as a computer terminal. This combination will allow the greater use of your home microcomputer today and in the future. What follows is a brief description of a SOL system based on my personal experiences.

Hardware

My microprocessor, a SOL-20, uses an 8080 processor chip. (The 8080A and the 9080A are also available.) This system has both parallel and serial communication interfaces, a keyboard interface, audio cassette interface, a video display generator, 1024 8 bit words of volatile system memory, and 1024 8 bit words of volatile display refresh memory. My system also has 8 K

bytes of volatile main user memory for programming and an operating system in a "personality module" with preprogrammed read only memories.

A feature of the hardware is a parallel interface consisting of eight bits for each input and output plus control handshaking signals. The output bus uses three state TTL levels for bidirectional interfaces. The serial interface circuit includes both asynchronous RS-232 and 20 mA current loop provisions and operates at from 75 to 9600 bits per second, switch selectable. (When I say that something is switch selectable, I mean that there is a series of small switches on the printed circuit board and an explanation in the hardware manual of what the switch does and what your options are.) The keyboard interface handles a 7 level ASCII encoded TTL keyboard which requires a strobe pulse after the data is stable.

The audio cassette interface is program controllable and self-clocking with a phase lock loop. It operates at the dual rate of 300 or 1200 bits per second. Included is an automatic level control in both the record and playback modes. Recording is the CUTS/BYTE standard compatible, an asynchronous Manchester code at 1200/2400 Hz or 600/1200 Hz.

The video display circuitry generates 16 lines from data stored in its 1 K refresh memory. Alphanumeric and control characters (the character set includes all upper and lower ASCII plus control characters) are displayed in either black on white or white on black (this feature is switch selectable). The solid video cursor with a switch selectable blink is programmable. This circuitry can drive any video monitor or monochrome television converted to handle video input.

The assembly of the SOL appears to be relatively easy. I bought my SOL fully assembled, but I read the assembly instructions, looked at the diagrams, and thoroughly examined the hardware. I believe that I could quite easily put a SOL together. The instructions are simple and straightforward. The assembly notes include parts lists, assembly tips and precautions, pictures and drawings, and step-by-step instructions on assembly and testing. Also included are instructions on handling integrated circuits, soldering techniques, and a list of the tools that will be needed. Processor Technology provides schematic and detailed assembly drawings in a separate section of their manual.

Another important feature of the SOL is the system's completeness and modularity. All of the hardware is in one package and looks like a large electric typewriter. The video monitor and cassette recorders are attached at the back panel with cables. The system does not have exposed boards or parts to collect dust or be damaged. The system can be easily transported.

DUMP	ADDR, ADDR	Dump memory locations to screen
ENTER	ADDR	Enter data to memory
TLOAD		Load to memory
EXECUTE	ADDR	Execute a program at a given address
BASIC		Execute a program located at address zero
TERMINAL		Return to terminal mode

Table 1: CONSOL operating system command summary.

DUMP	ADDR, ADDR	Dump memory locations to screen
ENTER	ADDR	Enter data to memory
TLOAD		Load data from tape to memory
EXECUTE	ADDR	Execute a program at a given address
BASIC		Execute a program located at address zero
TERMINAL		Return to terminal mode
TSAVE (NAME)	ADDR, ADDR	Save certain memory locations on tape
TXEQ (NAME)	ADDR	Load a certain program from tape and execute it
TCAT		List tape header information
SET		Allows the setting of the following things
SET DI		Set display speed
SET IN		Set input driver
SET OUT		Set output driver
SET TAPE		Set tape speed
SET CI		Set custom input driver address
SET CO		Set custom output driver address
SET TY		Set types into tape save header
SET XE		Set execute address into tape save header

Table 2: SOLOS operating system command summary.

Operating Systems

SOL, at present, has three operating systems. They are CONSOL, SOLED and SOLOS. CONSOL allows simple terminal operations and computer functions. SOLED allows more advanced terminal operations than CONSOL with additional screen, file and cassette tape operations. SOLOS allows use of the full range of the microprocessor plus the full functions of an intelligent terminal. I cannot describe SOLED any further, not having the information available to me. However, CONSOL and SOLOS will be described in detail.

CONSOL, the simplest of these operating systems, allows the SOL to function both as a standard CRT terminal and as a microcomputer. This software system is not as sophisticated as SOLOS which has many more commands and greater abilities.

All the operating systems work in the following fashion. The same switch to power up the hardware serves to initialize the operating system. The operating system initializes system memory, clears the screen and enters the terminal mode. Depressing the mode key causes SOL to operate as a microcomputer. The operating system issues a prompt character and awaits further commands.

```
10 REM THIS PROGRAM IS FOR TEACHING YOUNGSTERS MULTIPLICATION.
20 PRINT "DO YOU WANT TO TRY THE MULTIPLICATION PROGRAM?"
30 PRINT "ANSWER 1 FOR YES, AND 2 FOR NO."
40 INPUT X
50 IF X=2 THEN 340
60 PRINT
70 PRINT "INPUT THE FIRST NUMBER."
80 INPUT A
90 PRINT A;" TIMES"
100 PRINT
110 PRINT "INPUT THE SECOND NUMBER."
120 PRINT B
130 PRINT A;" TIMES";;B;" EQUALS"
140 PRINT
150 PRINT "INPUT WHAT YOU THINK THE ANSWER SHOULD BE."
160 J=A*B
170 INPUT C
180 PRINT A;" TIMES";B;" EQUALS";C
190 IF C=J THEN 260
200 PRINT
210 PRINT "YOUR ANSWER WAS INCORRECT."
220 PRINT
230 PRINT A;" TIMES";B;" EQUALS";J
240 PRINT
250 GOTO 290
260 PRINT
270 PRINT "CONGRATULATIONS, YOUR ANSWER WAS CORRECT."
280 PRINT
290 PRINT "DO YOU WANT TO CONTINUE?"
300 PRINT "ANSWER 1 FOR YES, AND 2 FOR NO."
310 INPUT X
320 IF X=2 THEN 340
330 GOTO 60
340 PRINT
350 PRINT "HAVE A NICE DAY!"
360 END


*RUN


DO YOU WANT TO TRY THE MULTIPLICATION PROGRAM?
ANSWER 1 FOR YES, AND 2 FOR NO.
?1

INPUT THE FIRST NUMBER.
?2
    2  TIMES

INPUT THE SECOND NUMBER.
?2
    2  TIMES    2  EQUALS

INPUT WHAT YOU THINK THE ANSWER SHOULD BE.
?2
    2  TIMES    2  EQUALS   2

YOUR ANSWER WAS INCORRECT.

    2  TIMES    2  EQUALS   4

DO YOU WANT TO CONTINUE?
ANSWER 1 FOR YES, AND 2 FOR NO.
?1

INPUT THE FIRST NUMBER.
?2
    2  TIMES

INPUT THE SECOND NUMBER.
?2
    2  TIMES    2  EQUALS

INPUT WHAT YOU THINK THE ANSWER SHOULD BE.
?4
    2  TIMES    2  EQUALS   4

CONGRATULATIONS, YOUR ANSWER WAS CORRECT.

DO YOU WANT TO CONTINUE?
ANSWER 1 FOR YES, AND 2 FOR NO.
?2

HAVE A NICE DAY!
```

Listing 1: A tutorial BASIC program of the simplest variety, created one evening to instruct a 6 year old in some of the complexities of arithmetic.

There are five commands for operating SOL as a microcomputer under CONSOL, two for entering data, two for executing programs, and one for displaying the contents of memory on the monitor. (See table 1 for the complete list of CONSOL commands.) A person can enter data either through the keyboard by means of the ENTER command or through a cassette tape recorder by means of the TLOAD command. The ENTER command permits the altering of any byte or series of bytes of storage with either data or a machine language program. Program execution begins with the issuance of either of two commands. EXECUTE allows the execution of a program beginning at any point that you name in memory, whereas the issuance of the BASIC command starts program execution from memory location zero. The fifth command, DUMP, allows the displaying of any byte or series of bytes on the video monitor.

The SOLOS operating system allows for more advanced operation of the SOL. (See table 2 for a complete list of SOLOS commands.) Besides the six basic commands allowed under CONSOL, there are four additional commands, with one of these additional commands, SET, having eight different options. To begin with, the TLOAD command is different under SOLOS than under CONSOL. Under SOLOS, the TLOAD command allows the searching of a tape with multiple files for a certain named file, skipping over all files before it. Under CONSOL, you have to manually move the tape to the beginning of the tape file.

TSAVE allows the saving on tape of the contents of the memory locations indicated. TXEC allows the loading of a named program from tape to memory and the immediate execution of that program. TCAT allows the listing of the tape file header information on the monitor. This information includes the file name, execution address, and the beginning and ending addresses of the program when loaded to memory.

The SET command has eight different options. One can set the display speed, allowing the speeding up and slowing down of characters on the monitor to suit your programming. Using this option of the BASIC language interpreter, I was able to generate a very impressive lightning bolt image for my young son and his friends. The input and output driver speeds can be controlled through the use of the SET command along with the tape speed, and

the input and output driver addresses. The tape save headers can also be altered using SET. The more useful of the two operating systems is obviously SOLOS since it allows greater flexibility.

Software

My system has a BASIC interpreter, the BASIC-5 package. This interpreter has many of the usual BASIC commands and statements. It also allows use of system commands within programs. BASIC-5 allows the usage of single dimension arrays, many BASIC functions, and the ability to read and write tapes. It also has 8 digit precision and the ability to link to machine language subprograms.

I would advise the purchase of the 8 K BASIC for one important reason: the ability to have several commands and features not available in the BASIC-5 interpreter. These would be the RNUM command which allows the renumbering of statements, and also the ability to utilize alphanumerics and matrices (instead of only single dimension arrays) which would be particularly useful.

Uses

I have utilized my SOL for several things. First and foremost, I have introduced my 6 year old son to computers through games and learning programs, such as the multiplication program reproduced and described in listing 1. I have also used it for entertainment especially through the use of the target game provided by Processor Technology, and a few games I have written. Lastly, I have used it to fool around with my first love, history. I have written several statistical analysis programs for the SOL using the BASIC-5 software to continue with my research on colonial New England. Also reproduced here, as listing 2, is a sample of a simple program to do elementary fertility figures.

I have reproduced and wholly written a few programs to assist in the mathematical education of my son. MULT and two other programs have been written as interactive quizzing programs to test and teach mathematics through praise when he is correct and by showing him the correct way when he is wrong. Thus the computer acts as a teacher and could be utilized in this fashion in every home and classroom for elementary school aged children. More sophisticated programs could be implemented on the SOL for older children. These programs, in the form of games, could serve two purposes, entertainment and education.

Listing 2: A sample of a statistical BASIC application typical of programs used by the author in his avocation of historical studies.

```
10 PRINT"THIS PROGRAM WILL PRODUCE FERTILITY FIGURES"
11 PRINT"FOR THE DATA INPUT. THE OUTPUT CONSISTS OF"
12 PRINT"THE PROPORTION OF BIRTHS TO MARRIAGES OVER"
13 PRINT"A DECADE WITH FIVE YEAR INCREMENTS BETWEEN DATA."
14 PRINT"THESE FERTILITY FIGURES (THE BIRTH RATE) CONSIST OF"
15 PRINT"THE NUMBER OF BIRTHS FOR A DECADE DIVIDED BY THE"
16 PRINT"NUMBER OF MARRIAGES FOR A DECADE WHICH BEGAN FIVE"
17 PRINT"YEARS EARLIER."
65 D1=0
66 I=0
100 PRINT"INPUT THE STARTING YEAR (BETWEEN 1650/1795) DESIRED     "
105 INPUT Y
106 PRINT"INPUT THE NUMBER OF SETS OF YEARS OF DATA                "
107 INPUT D
110 PRINT"INPUT THE NUMBER OF FIVE YEAR INCREMENTS DESIRED         "
120 INPUT N
128 DIM Y1(40),M1(40),B1(40),F1(40),Y2(40)
129 DIM F2(40),Y3(40)
130 FOR J=1 TO D
140 READ Y1(J),M1(J),B1(J)
160 NEXT J
195 PRINT"           MARRIAGE YEARS            FERTILITY"
200 FOR J=1 TO D
205 IF I=N THEN 340
210 IF Y1(J)<Y THEN 290
220 Y2(J)=Y1(J+2)-1
230 F1(J)=(B1(J+1)+B1(J+2))/(M1(J)+M1(J+1))
250 PRINT Y1(J),Y2(J),F1(J)
260 S=S+F1(J)
270 D1=D1+1
280 I=I+1
285 F2(I)=F1(J)
286 Y3(I)=Y1(J)
290 NEXT J
340 M=S/D1
350 PRINT"MEAN OF FERTILITY FIGURES                                 ";M
395 PRINT
396 PRINT
398 PRINT " YEAR                    FERTILITY"
399 PRINT"+++++++++++++++++++++++++++++++++++++++++++++++++++++"
400 FOR K=1 TO I
420 L=INT((F2(K)*10)/2)
430 PRINT Y3(K);"++";TAB(L);"*"
490 NEXT K
500 PRINT"+++++++++++++++++++++++++++++++++++++++++++++++++++++"
900 DATA 1650,5,28,1655,8,32,1660,14,43,1665,9,44
910 DATA 1670,20,78,1675,18,90,1680,26,125,1685,29,168
920 DATA 1690,24,163,1695,20,156,1700,24,179,1705,34,196
930 DATA 1710,54,239,1715,40,247,1720,64,287,1725,66,289
940 DATA 1730,84,333,1735,88,328,1740,88,371,1745,92,354
950 DATA 1750,87,372,1755,105,365,1760,88,388,1765,80,377
960 DATA 1770,65,342,1775,80,311,1780,108,298.1785,105,344
970 DATA 1790,118,228,1795,99,350
999 END
```

```
THIS PROGRAM WILL PRODUCE FERTILITY FIGURES
FOR THE DATA INPUT. THE OUTPUT CONSISTS OF
THE PROPORTION OF BIRTHS TO MARRIAGES OVER
A DECADE WITH FIVE YEAR INCREMENTS BETWEEN DATA.
THESE FERTILITY FIGURES (THE BIRTH RATE) CONSIST OF
THE NUMBER OF BIRTHS FOR A DECADE DIVIDED BY THE
NUMBER OF MARRIAGES FOR A DECADE WHICH BEGAN FIVE
YEARS EARLIER.
INPUT THE STARTING YEAR (BETWEEN 1650/1795) DESIRED:
?1650
INPUT THE NUMBER OF SETS OF YEARS OF DATA:
?30
INPUT THE NUMBER OF FIVE YEAR INCREMENTS DESIRED:
?20
           MARRIAGE YEARS            FERTILITY
       1650           1659           5.769231
       1655           1664           3.954545
       1660           1669           5.304348
       1665           1674           5.793100
       1670           1679           5.657895
       1675           1684           6.659091
       1680           1689           6.018182
       1685           1694           6.018868
       1690           1699           7.613636
       1695           1704           8.522727
       1700           1709                7.5
       1705           1714           5.522727
       1710           1719           5.680851
       1715           1724           5.538462
       1720           1729           4.784615
       1725           1734           4.406667
       1730           1739           4.063953
       1735           1744           4.119318
       1740           1749           4.033333
       1745           1754           4.117318
MEAN OF FERTILITY FIGURES:    5.553943
```

Circle 64 on inquiry card.

Listing 2, continued:

```
 YEAR                  FERTILITY
+++++++++++++++++++++++++++++++++++++++++++++++++++++
 1650 ++                      *
 1655 ++             *
 1660 ++                    *
 1665 ++                      *
 1670 ++                      *
 1675 ++                           *
 1680 ++                        *
 1685 ++                        *
 1690 ++                                *
 1695 ++                                    *
 1700 ++                               *
 1705 ++                     *
 1710 ++                      *
 1715 ++                     *
 1720 ++                 *
 1725 ++                *
 1730 ++              *
 1735 ++              *
 1740 ++              *
 1745 ++              *
++++++++++++++++++++++++++++++++++++++++++++++++++++++
```

In closing, I find the SOL system easy to use, fun to program, and important in our home. It provides my family with entertainment in the form of games both from Processor Technology and written by us. It also provides a mathematics tutor at home for my son. It has also given my son an interest in and understanding of computers far beyond his years and education. I definitely recommend the SOL, based on my experiences with it.■

Circle 51 on inquiry card.

BYTE's Bits

Dallas to Host AAME Exposition

The International Microcomputer Exposition will be held in the Dallas TX Convention Center, September 29 through October 1 1978. The exposition, cosponsored by The American Association of Microprocessor Engineers (AAME) and other groups, will be directed toward all levels of technology from the engineer to the novice. Seminars and panel discussions will be held, and over 250 exhibits are planned. For more information, contact Beverly Tanner at (214) 271-9311.■

A Conference in Texas

1978 Computer Users' Conference will be held on April 20 and 21 at East Texas State University, Commerce TX. The theme will be "Reality in the Computer World" with the session topics being "Using the Computer *AS* a Profession" and "Using the Computer *IN* a Profession."

In addition to keynote speeches, industrial and educational representatives will hold panel discussions of current and future computer science curricula for the respective computer usage areas.

Fees for the conference are $20 ($10 for students). For further information contact Donna Hutcheson, Computer Users' Conference Coordinator, East Texas State University, Department of Computer Science, Commerce TX 75428, (214) 468-2954.■

Cruise Interfacing. . . Join a Seaborne Microcomputer Workshop

An advanced Microcomputer Interfacing and Programming Workshop to be presented on a 7 day Caribbean cruise has been announced by the Extension Division of Virginia Polytechnic Institute and State University. The workshop is scheduled to be presented aboard the TSS Carnivale from June 17 thru 24. It will consist of an introductory session followed by five daily sessions of six hours of lecture and laboratory work. The course content is designed for scientists, engineers and executives who have prior knowledge of basic digital electronics and microcomputer interfacing and programming techniques.

The course is being offered in cooperation with the departments of chemical engineering, chemistry and extension at Virginia Polytechnic Institute and State University. The instructors for the course will be Professors Peter Rony, David Larsen and Paul Field. It is the latest in a series of over 30 seminars which have been presented by this group. Text and laboratory workbook material for the course includes several new books in the Bugbook series, authored by the instructors and their colleagues. Participants will work in pairs on their laboratory experiments using a complete 8080a microcomputer and breadboarding station. The stations will be assigned for the duration of the course so that additional work may be done in the participants' staterooms.

Norris Bell, director of VPI's Continuing Education Center, said that the cruise ship course is the result of a search for new and interesting ways of providing continuing education. Additional information on the course and on the travel agency handling the arrangements are available from the Registrar, CEC, VPI & SU, Blacksburg VA 24061, (703) 951-5182.■

Robot Simulation on Microcomputers

Why build a mechanism when a video display can be used to visualize logical problems of robots?

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CANADA

A short time ago I came across a program *(Dr Dobb's Journal*, volume 1, number 8, page 28) written by Marvin Winzenread, entitled "The Bouncing Beastie: A Random Walker for Processor Tech's VDM-1." When I loaded the program, sure enough, this little thimble with feet appeared and began stumbling around the screen leaving a trail of asterisks. That was it. No big deal, you say? Marvin says the little character looks like a turtle to him, but to me it looked like the robot I'd tried to build when I was in high school, and I was entranced.

I'm one of those people who has always wanted to build a robot, but never quite did it for various reasons.

Part of the problem is that once you figure out approximately *how* to build, say, a simple little robot that will wander around your living room bouncing off furniture, then there isn't really much point in going to all the trouble and expense of actually building it. You already know what it's going to do, and it wouldn't really be all *that* useful.

Another factor is that the hardware robots will need already exists and isn't likely to change all that much in the foreseeable future. The thing that's lacking is the software. If we had the proper programs we would all have robots today.

Watching Marvin's surprisingly fascinating little creature bounce around the screen, it occurred to me that a very interesting, entertaining and hopefully useful alternative to actually building robots might be to simulate them on a microcomputer television display. Thus, my microbots were born. Microbots are simulated robots that move about a simulated room (the television screen) under software control. With microbots you can spend your time thinking up new things for them to do and testing robot related software without worrying about the hardware.

"Microbot" is a simple 8080 machine language microbot driver program that provides a starting point for robot related program development.

In its present form (see figure 1 and listing 1) the program begins with a microbot creature starting in the center of an empty room. It then makes a move in one of eight random directions for a randomly chosen distance (of one to four squares). The microbot will sense the perimeter wall and reject any random moves that would make it walk "into" the wall. It will also reject a move that is in the opposite direction of the previous one. This prevents "bouncing" and produces a more realistic movement pattern.

A call to a random number generator (RND) first selects the 180° sector for the next move by setting bit 4 of the present direction status word (DSW) to either one or zero. The subroutine REC stores this information at hexadecimal location 14D and moves the previous contents of 14D (the DSW for the previous move) to 14E for later comparison.

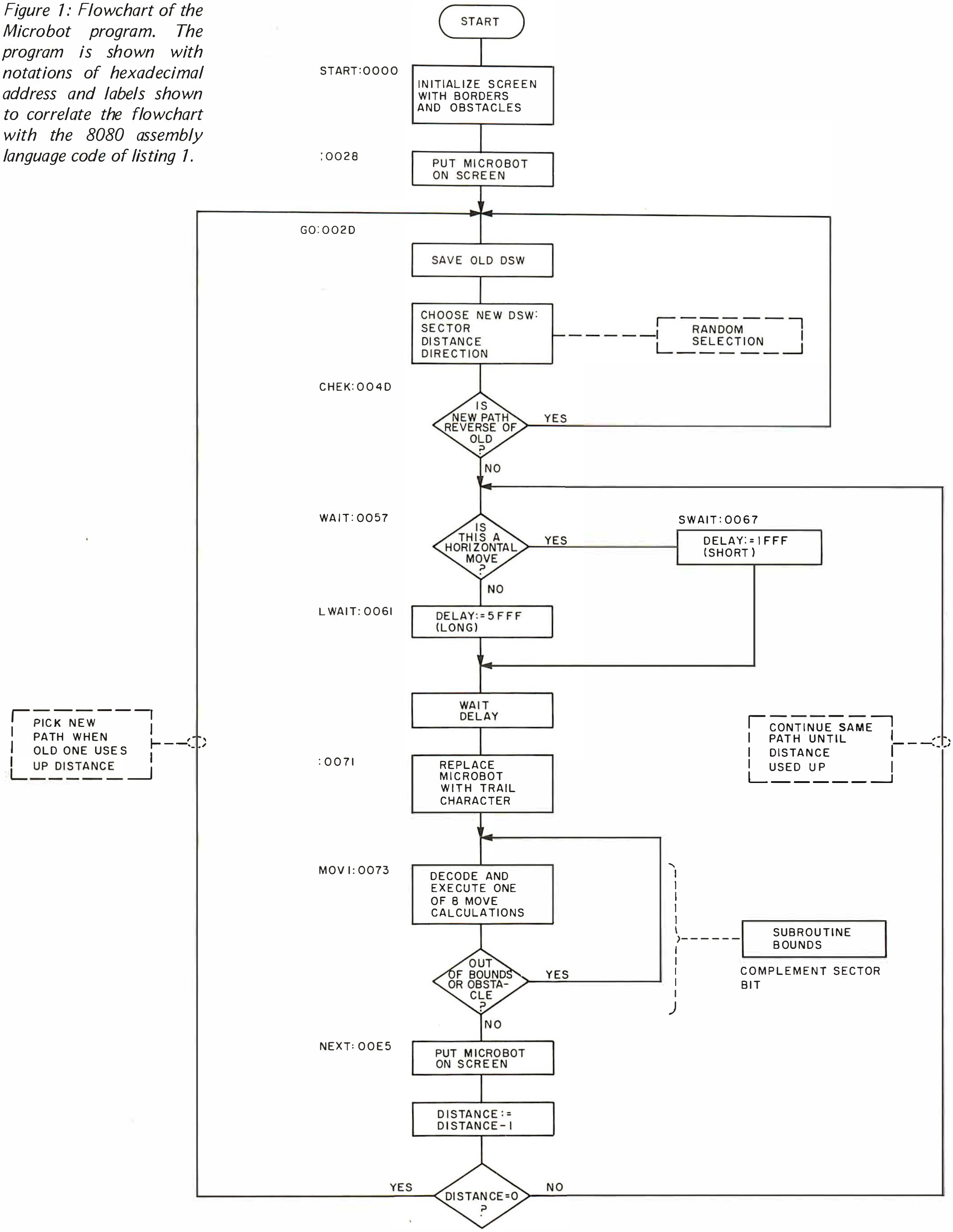
A second call to the random number generator provides one of the four possible moves within the chosen sector. This value (00, 01, 02, or 03 hexadecimal) is then added to the data in 14D to produce the final direction status word for the present move.

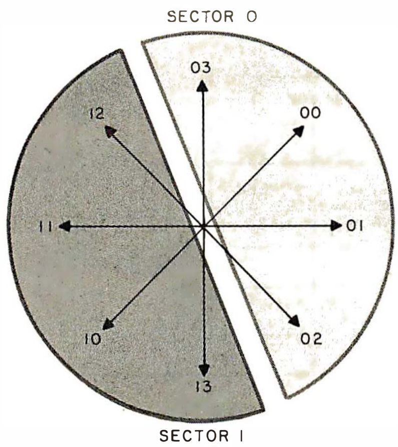
Figure 2 illustrates the eight possible moves and their associated status words. Notice that opposite directions are indicated by the state of bit 4 of the direction status word. This fact is used in the present program to disallow immediate reverse moves. It also makes it simple to reverse direction when desired by the programmer.

There are three status words used in the present program. Location 14D contains the present direction status word; location 14E contains the direction status word of the previous move; location 14F contains a distance status word (DIS) that determines the length of the present move.

The program segment CHEK then

Figure 1: Flowchart of the Microbot program. The program is shown with notations of hexadecimal address and labels shown to correlate the flowchart with the 8080 assembly language code of listing 1.





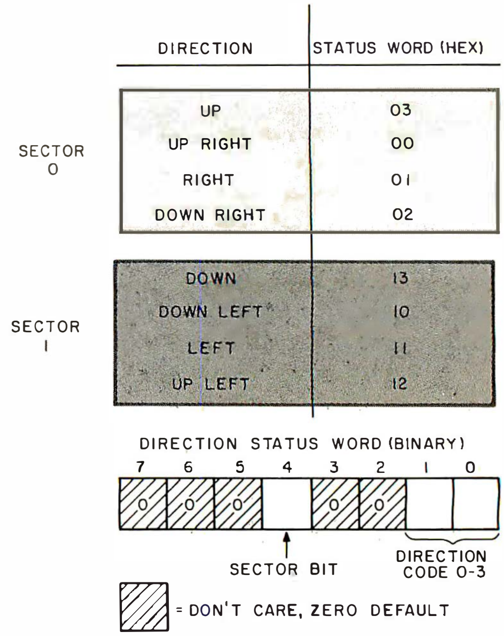


Figure 2: In the representation used for direction status words (DSWs) in the Microbot program, the possible directions break down into two sectors based on the status of bit 4 of the DSW byte. The two low order bits determine the direction within each sector according to the diagram.

compares the present and previous direction status words to see if they are in opposite directions. If they are, a new direction status word is sought.

Next, wait routines are inserted to slow the movement to a realistic speed. The speed of your microbot can be varied by changing the constants at hexadecimal locations 63 and 69. WAIT checks to see if the present move is horizontal or not. A longer wait is used for horizontal moves to compensate for the fact that there are 64 horizontal and only 16 vertical positions on the VDM-1 display.

A "trail" character is then inserted on the present square and the direction status word is decoded with a resulting jump to one of eight move routines. Any noncursor character may be inserted at location 72 as a trail character. After completing the proper move, the subroutine BOUNDS is called to determine whether or not the microbot is trying to move to an obstacle position (ie: any square containing a cursor). If it is, bit 4 is complemented and the resulting move returns microbot to his previous position, effectively cancelling the disallowed move. Each move routine ends with a jump to NEXT which writes the microbot character into the new position square and checks the distance status word. Depending on the contents of DIS, either the last move is repeated or the program jumps back to GO to initiate a new random move.

Future Expansion

As the purpose of this article is to present a basic concept and program for others to expand, let's look at some possible areas of development:

1. Search Efficiency: As many robot systems will incorporate search or random search routines, the VDM display allows an excellent theatre for study of the efficiency of various approaches. A measure of the average time it takes a microbot to fill all screen squares with his trail would provide indication of the efficiency of his move pattern. Various changes could be made to microbot's move routines and the results analyzed.

   If Microbot's "room" of 16 x 64 squares proves too small for your needs, rooms of any size may be constructed and stored away in 1 K memory sectors. A check to sense that the creature was moving off the side of the screen could be used to call up another sector, move it to the screen and allow microbot to enter on the opposite side. Also, the same algorithm could be easily extended to displays with a higher resolution.
2. Learning: Some of the most complex and interesting programming work to be done is in the field of artificial intelligence and robot "learning." Microbot's use of direction status words should provide a capability for storing, retaining and modifying (eg: retracing steps) move paths that might be kept for future reference if useful, or discarded by the program if inappropriate or less efficient. Refer to texts on artificial intelligence for much more detailed discussions of what it

```
0000  31 57 01   START  LXI   SP,0157H
0003  AF                XRA   A
0004  D3 C8             OUT   0C8H
0006  16 0E             MVI   D,0EH
0008  21 00 CC          LXI   H,OCC00H
000B  01 42 A0          LXI   B,0A042H
000E  CD 08 01          CALL  LOAD
0011  01 3C 20   SCRN   LXI   B,0203CH
0014  CD 08 01          CALL  LOAD
0017  01 40 A0          LXI   B,0A004H
001A  CD 08 01          CALL  LOAD
001D  15                DCRD
001E  BA                CMPD
001F  C2 11 00          JNZ   SCRN
0022  01 3E A0          LXI   B,0A03EH
0025  CD 08 01          CALL  LOAD
0028  21 20 CE          LXI   H,0CE20H
002B  36 07             MVI   M,07H
002D  CD 1A 01   GO     CALL  RND
0030  E6 02             ANI   02H
0032  CA 37 00          JZ    RC
0035  3E 10             MVI   A,010H
0037  CD 10 01   RC     CALL  REC
003A  CD 1A 01   DIS    CALL  RND
003D  32 4F 01          STA   014FH
0040  CD 1A 01   DIR    CALL  RND
0043  47                MOV   B,A
0044  3A 4D 01          LDA   014DH
0047  E6 10             ANI   010H
0049  80                ADD   B
004A  32 4D 01          STA   014DH
004D  47         CHEK   MOV   B,A
004E  3A 4E 01          LDA   014EH
0051  A8                XRA   B
0052  FE 10             CPI   010H
0054  CA 40 00          JZ    DIR
0057  3A 4D 01   WAIT   LDA   014DH
005A  E6 0F             ANI   OFH
005C  FE 01             CPI   01H
005E  CA 67 00          JZ    SWAIT
0061  01 FF 5F   LWAIT  LXI   B,5FFFH
0064  C3 6A 00          JMP   DEC
0067  01 FF 1F   SWAIT  LXI   B,1FFFH
006A  0B         DEC    DCXB
006B  78                MOV   A,B
006C  FE 00             CPI   00
006E  C2 6A 00          JNZ   DEC
0071  36 20             MVI   M,020H
0073  3A 4D 01   MOV1   LDA   014DH
0076  FE 00             CPI   0
0078  CA 9E 00          JZ    UR
007B  FE 01             CPI   01H
007D  CA A8 00          JZ    RT
0080  FE 02             CPI   02H
0082  CA AF 00          JZ    DR
0085  FE 13             CPI   013H
0087  CA B9 00          JZ    DN
008A  FE 10             CPI   010H
008C  CA C3 00          JZ    DL
008F  FE 11             CPI   011H
0091  CA CD 00          JZ    LFT
0094  FE 12             CPI   012H
0096  CA D4 00          JZ    UL
0099  FE 03             CPI   03H
009B  CA DE 00          JZ    UP
009E  11 C2 FF   UR     LXI   D,00FFC2H
00A1  19                DAD   D
00A2  CD F6 00          CALL  BOUNDS
00A5  C3 E5 00          JMP   NEXT
00A8  23         RT     INX   H
00A9  CD F6 00          CALL  BOUNDS
00AC  C3 E5 00          JMP   NEXT
00AF  11 42 00   DR     LXI   D,042H
00B2  19                DAD   D
00B3  CD F6 00          CALL  BOUNDS
00B6  C3 E5 00          JMP   NEXT
00B9  11 40 00   DN     LXI   D,040H
00BC  19                DAD   D
00BD  CD F6 00          CALL  BOUNDS
00C0  C3 E5 00          JMP   NEXT
00C3  11 3E 00   DL     LXI   D,03EH
00C6  19                DAD   D
00C7  CD F6 00          CALL  BOUNDS
00CA  C3 E5 00          JMP   NEXT
00CD  2B         LFT    DCX   H
00CE  CD F6 00          CALL  BOUNDS
00D1  C3 E5 00          JMP   NEXT
00D4  11 BE FF   UL     LXI   D,0FFBEH
00D7  19                DAD   D
00D8  CD F6 00          CALL  BOUNDS
00DB  C3 E5 00          JMP   NEXT
00DE  11 C0 FF   UP     LXI   D,0FFCOH
00E1  19                DAD   D
00E2  CD F6 00          CALL  BOUNDS
00E5  36 07      NEXT   MVI   M,07H
00E7  3A 4F 01          LDA   014FH
00EA  3D                DCR   A
00EB  32 4F 01          STA   014FH
00EE  FE FF             CPI   OFFH
00F0  CA 2D 00          JZ    GO
00F3  C3 57 00          JMP   WAIT
00F6  7E         BOUNDS MOV   A,M
00F7  E6 80             ANI   080H
00F9  C8                RZ
00FA  33                INX   6
00FB  33                INX   6
00FC  3A 4D 01          LDA   014DH
00FF  0E 10             MVI   C,010H
0101  A9                XRA   C
0102  32 4D 01          STA   014DH
0105  C3 73 00          JMP   MOV 1
0108  70         LOAD   MOV   M,B
0109  23                INX   H
010A  0D                DCRC
010B  B9                CMPC
010C  C8                RZ
010D  C3 08 01          JMP   LOAD
0110  E5         REC    PUSH  H
0111  21 4D 01          LXI   H,014DH
0114  4E                MOV   C,M
0115  77                MOV   M,A
0116  23                INX   H
0117  71                MOV   M,C
0118  E1                POP   H
0119  C9                RET
011A  E5         RND    PUSH  H
011B  21 44 01          LXI   H,SH+3
011E  06 08             MVI   B,08H
0120  7E                MOV   A,M
0121  07         RTOP   RLC
0122  07                RLC
0123  07                RLC
```

Listing 1: The Microbot program, assembled for an 8080 system which has the Processor Technology VDM-1 board located at hexadecimal locations CC00 to CFFF in memory address space (1024 bytes).

```
0124   AE                    XRA   M
0125   17                    RAL
0126   17                    RAL
0127   2D                    DCRL
0128   2D                    DCRL
0129   2D                    DCRL
012A   7E                    MOV   A,M
012B   17                    RAL
012C   77                    MOV   M,A
012D   2C                    INRL
012E   7E                    MOV   A,M
012F   17                    RAL
0130   77                    MOV   M,A
0131   2C                    INRL
0132   7E                    MOV   A,M
0133   17                    RAL
0134   77                    MOV   M,A
0135   2C                    INRL
0136   7E                    MOV   A,M
0137   17                    RAL
0138   77                    MOV   M,A
0139   05                    DCRB
013A   C2  21  01            JNZ   RTOP
013D   E6  03                ANI   03H
013F   E1                    POP   H
0140   C9                    RET
0141               SH        DS    4
0145               AR        DS    6
                             END
```

means for a program to "learn."

3. Sensing the Environment: Simulation of optical, audio or tactile sensors would be very easy with microbots. Remote squares could be examined by microbots' "eyes," for example, according to any rules or limitations (such as distance and direction) the programmer wishes to impose. Experiment with obstacles of different shapes. Color or texture differentiation may be simulated by using other obstacle characters in addition to cursors, eliciting different responses from your creature. A starting point might be to have your microbot periodically scan one wall, searching for an "object" partially obscured by obstacles.

   Other interesting possibilities would arise with two microbots in the same room leaving different trails and searching for each other. If you decide to explore this area, you might want to give toes to your microbots, so one microbot can tell which way the other's trail leads. Leaving a trail of three sequential numbers instead of asterisks might be one way.

4. Work: If you had a little robot running around your house, what would you like it to do? Vacuum the floor? Pick up small objects and put them away? How about a robot that checks your

000	001	002	003	004	005	006	007	008	009	010	011	012	013	014
0000	001A	0033	004C	0064	007C	0094	00AC	00C5	00DD	00F5	010D	0125	013C	

000	001	002	003	004	005	006	007	008	009	010	011	012	013	014

Figure 3: The PAPERBYTES^{tm} bar code representation of the object code for the Microbot 8080 program by John Webster. The standard bar code frame format is used, with its synchronization byte (hexadecimal 96) followed by checksum byte, line identification byte, line length byte and data field. The data field of each frame uses the "absolute" format consisting of a 2 byte address followed by data to be stored at that address. The assembly of listing 1 was also typeset by machine from the same data file and contains the source code as well as the object code found in this bar code representation.

The documentation of bar code loader programs suitable for loading this program with the data in this figure is found in the book Bar Code Loader *by Ken Budnick, available for $2 at local computer stores and by mail from BITS Inc, 70 Main St, Peterborough NH 03458. To read this data will require a homebrew or commercially manufactured bar code scanning wand, using procedures outlined in Ken Budnick's book.*

potted plants and waters them if they need it? Or why not all these things at once? The possibilities are really limitless. Microbots will allow you to develop and test logical procedures for solving all of these problems.

5. **Feeding Time**: Don't forget that you are simulating a real working robot and that certain internal housekeeping routines should be built in.

Since any self-respecting real world robot will run on rechargeable batteries, a timer or move counter should be one of the first things built into your program to simulate "low batteries" and to initiate a search and docking routine for recharge at one or more "power stations" in the "room." Of course, you also have to remember to empty the vacuum cleaner or whatever.

Conclusion

Sound interesting? Why not run Microbot and see what ideas occur to you? What robots really need right now is for lots of computer hobbyists to start thinking and working on their software. Oh yes, in case I forgot to mention it in my enthusiasm, it's also a lot of fun.■

Continued from page 6

varies from artist to artist. Sometimes the medium of the representation itself seems to take on more importance for the artist than the aesthetics and inputs from reality. But works of art do not grow by accident, they are created by the designs of the artist.

One way to describe a theory of science is as a *selective representation* of reality created (and tested) by the scientist in an attempt to *understand* reality. By its nature, the selection criteria of science tend to be more demanding of precision than those of the artist. These scientific selection criteria are independent of any one scientist, and the nature of the representation is invariably the written word expressed in one or another mathematical formalism. But theories of science do not grow by accident either; they are created and tested by scientists.

The key concept in both these informal definitions is that of the selective representation of some aspect of reality. In art this may be transformed to such an extent that the input from reality is difficult to see. In science the representation may be so abstract that only those who are at the frontiers of research may yet understand the theory. But both are selective representations, with the selection activity performed by the creator of the work of art or theory of science. The activities of the mind of the artist or scientist are what I refer to as the "intellect." To see the impact of personal computers on these two forms of intellectual activity, we must examine the nature of the computer in its role of intellectual amplifier.

Enter the Intellectual Amplifier

The change of state represented by the contemporary technology of the personal computer is characterized by the growing use of these "intellectual amplifiers" by the individual citizen. We are leaving the state of the inaccessible computer in its computing center, and entering the state of the self contained and inexpensive personal computer. The essences of the computer's contribution to the mental processes of art and science are the same: automation of well understood processes, and speeds of real time operation impossible for unaided human beings.

A characteristic of the creative intellect is the tendency to compartmentalize an activity, isolate its essentials. The whole activity may be too complex to handle at all if this is not done. We find the artist working in oils dividing a complicated

picture into regions of detail according to his plan for the picture; we find the composer of music selecting a theme or set of themes which is then woven into a fabric of variations and harmonic structure which might constitute a piece of music; the scientist, given a hypothesis and its experimental context, orchestrates the methods and instrumentation procedures needed to test the significance of the hypothesis; the science educator chooses a logical structure of presentation of information in the field of a course. I call such activities "well understood" what to do: the process is unambiguously defined given the goals. The automation of such "well understood" processes is one of the major uses of the small computer systems we call personal computers. Once the process is known well enough to be expressed as a computer program, detailed thought about the sequencing and operation of that process can be set aside while turning attention to less well understood phenomena and processes. The result is an amplification of the mental powers of the individual who uses the small computer effectively.

A second aspect of the inexpensive personal computer is that of speeding up operations which can only be carried out slowly — if at all — by the human brain. The reaction times of the human nervous system are on the order of 10s of milliseconds in reflex situations. The time needed to think about anything significant is typically much longer. Thus if the human being is asked to respond to a phenomenon on the order of microseconds or milliseconds in duration, the task is impossible unaided. Just as the telescope with photographic emulsions or image intensifiers extends the resolution and light gathering power of the human eye, the computer can extend the response time and acuity of the human nervous system viewed as an instrument of process control, sequencing and measurement. This is an obvious advantage of the small computer to the scientist in the laboratory, but is just as useful to the artist in certain contexts.

Personal Computers: New Prospects for Science

With the basic principle of the "intellectual amplifier" characterized, what about some specific implications for the scientific user? In a sense, most practicing scientists

have in one way or another grown used to the use of computers over the past decades. In a way, the new low cost computers are but an extension of a trend that has seen a growing use of computer simulations, instrumentation with minicomputers, etc. The real implications are an enhancement of computers' utility due to increased accessibility made possible by low cost.

One interesting way to view the personal computer is as a new form of "logical" blackboard and chalk, pencil and eraser. There have been a number of articles in the world of traditional data processing covering the concept of "disposable" programs and languages in which to express such programs. In the same way that your standard blackboard is a "disposable" writing system for notation of theory being worked out, the accessible personal computer can be viewed as an instrument for quickly and interactively performing numerical and logical tests of the implications of a theory. Make no mistake about the role of the thinker in this: just as paper and pencil or blackboard and chalk are useless without thoughts to fill them, the personal computer as an interactive computational aid is similarly useless unless there are thoughts distilled into short disposable programs to keep it busy.

As an example of a simple use of the personal computer for a calculational scratchpad, I offer a program written by one of our authors, Paul Lutus, which will be published in the next few months in BYTE. The program is a numerical integration algorithm, where the function is specified explicitly in BASIC as, for example:

```
10 Y = SIN (X)
```

I loaded Paul's tape for the program into my Apple II and proceeded to explore some of the definite integrals of various functions. To do a course integration, this little program would be given a small number of points within the integration limits; to do a much finer integration (and possibly take a considerable amount of time) I would give it a larger number of points within the range of the integration. But the key point was that with such a program I was able to interactively explore the behavior of a class of problems (definite integrals) with variations of detail (the choice of function, integration limits, and number of iterations through the range of integration).

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This interactive programming example was not done, mind you, with a timesharing BASIC on a minicomputer or larger system, but on a self-contained 16 K system with extended BASIC which sells currently for $1700 and which has been offered at sale prices as low as $1300. When such a personal computer is sitting on a scientist's desk, then the concept of an interactive computational scratchpad becomes a reality.

But blackboards are used for more than just working out problems in isolation. One of the major functions of the traditional blackboard and chalk (or its equivalents) is communication of ideas to colleagues and students: education. The interactive personal computer with graphic capability is potentially a powerful teaching tool. Graphic demonstration of functions is often done in a handwaving sort of way by lecturers at a blackboard. I claim that the use of a small computer with television display graphics of moderate resolution and programs to calculate functions would perhaps be a more dramatic presentation. When taking a course in the theory of complex variables, for example, experimentally performing integrations along various contours could dramatize (and help the student internalize) the effects of the parameters of integration. When taking a course in quantum mechanics, wouldn't the computation and display of contours in a probability field help dramatize the concept graphically? The personal computer with graphic capability provides the teacher with the means to set up and illustrate mathematical behavior in numerous fields.

Of course, using the computer as an aid to the lecturer can be extended: there is a similar advantage to be had in the use of such experimenters as a part of interactive study outside of a lecture context. The new availability of small computers makes the concept of computer aided instruction take on new emphasis. Rote drill as well as thought problems can be cast into an interactive sequence which may be carried out by students using such a computer. Here the "well understood" process being automated is the process of conveying knowledge to a student and testing or reinforcing that knowledge.

The theoretical and pedagogical aspects of the personal computer used in a scientific context are largely in the category of "automating well understood processes" described earlier. Using the small computer system in an experimental or laboratory context represents another significant use. Here, the personal computer's use is but an extension of a trend which started with the first

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minicomputer ever sold to a research establishment. The computer becomes the high speed real time nervous system of the experiment, collecting data, sequencing events, and possibly doing limited forms of real time analysis and display. Many of the personal computers on the market are sold with sufficient documentation so that any competent laboratory technician can combine application software with several digital to analog or analog to digital converters, relays and miscellaneous sensors in order to implement the instrumentation of an experiment design at much less cost than might have previously been possible. Of course the computational abilities of the small computer in a laboratory situation allow significant portions of an experiment's analysis to be done on the same machine after the active portion of the experiment is completed.

In all this application of the small personal computer system to the real world of the scientist, there is one nontrivial danger: it is a possibility that the user of a computer will become intoxicated with the programming art, thus losing sight of the problem for which the program was desired. It is hard to imagine significant use of a computer without some form of programming, so the danger of getting lost in the details of the use of a computer is very real. Yet many experiments have been and continue to be done with computers, so the danger must not be insurmountable.

Personal Computers: New Prospects for Art

As noted earlier, I view art as the artist's selective representation of some aspects of reality to create an aesthetic effect. One key to any application of personal computers to art is the existence of specialized peripherals upon which to realize the representations chosen. It turns out that two classes of peripherals are typically found: the graphic image outputs useful as described for scientific as well as artistic purposes, and the audio output peripherals essentially useful only in a musical context. Given either or both of these classes of peripherals as an external representation, and the "intellectual amplifier" characteristics of the computer system driving them, some interesting new possibilities are available to the artist.

For the moment, just ignore the ability to calculate and sequence data to an artistic peripheral and consider the two classes of peripherals alone. The existence of a graphic display by itself allows traditional artistic functions to be done in a new medium. Similarly, the classic electronic music

synthesizer sans computer performs a traditional function (one instrumental sound) on a new medium. But then consider that an electronic medium is inherently subject to editing by a computer and to dynamically changing its pattern under control by a computer. Using a computer to control an audio output or a display, with progressions of displays varying in time, is what I call "algorithmic art." The essence of this entirely new art form is that simple mathematical principles can be used to create aesthetically satisfying visual or aural representations which can be classed as "art."

So let's turn first to the use of a personal computer to update a traditional technique. This is the technique of representing objects on a plane surface in multiple colors. A standard personal computer product, with no modifications necessary other than writing a small program to use a homebrew joystick, was used to create several visual representations stored in film. The program and some examples of this use were found in a review of the Apple II computer I wrote in the March 1978 BYTE. I employed the homebrew joystick for control of position in the limited resolution field of the display, an ordinary keyboard for setting of colors, and a button to allow colors to be extended while the cursor is moved about the screen. This is a simple and not particularly revolutionary technique.

Using the computational power of the computer, in the August 1977 BYTE, authors D John Anderson and William F Galway presented a short article on the subject of "Serendipitous Circles," a method of filling a display field with points based on an extremely simple algorithm with an inner loop containing just two computational steps outside of housekeeping functions. Depending upon the initialization of the parameters of the computation, an amazing variety of patterns is created, constantly changing in real time. Then, taking this algorithm one step further, a reader of BYTE, Kellerman, explored modifications of the algorithm and the principle of merging several generations of the display. The result was a short article and the cover of the April 1978 BYTE. The "Serendipitous Circles" algorithms are best calculated in real time, and with sufficiently fast displays they result in a dynamic form of art in which there is a pleasing visual progression with time. Here we have an example of art created by the design of the computational

algorithm. The graphic forms which result are the representation in two dimensions of the results of a computation; the artist selects the computation and thus determines what the display looks like. I can only view with some wonder the fact that the viewer can find the result of this simple computational technique so aesthetically pleasing.

As computers with good graphic capabilities come to market, algorithmic art is bound to become more important. One such example is used by the Apple Computer Company, for example, as part of a standard demonstration of what they call high resolution graphics. This example is the algorithm which computes a constantly changing colored pattern called the Spirograph. On a color television, it is like looking at a succession of different "mandala" designs of the sort usually created with colored string and pegs.

Turning to a different field, that of musical art, the use of the computer also creates exciting possibilities. With the appropriate synthesizer output peripherals, any personal computer can be used to control a personal orchestra in real time. (Well, depending on the number of channels, the orchestra might be more like a string quartet.) This is the "traditional" method of representing music, updated with the small computer acting as the logical equivalent of a player piano's roll.

The use of a digital representation of a musical score enables people to play music independently of muscular coordination and skill. It also allows complexity approaching the small orchestra to be managed by one artist. But that is not necessarily all there is to computerized music.

Using the "intellectual amplifier" characteristics of a processor between keyboard and music synthesizers, for example, algorithms for the assignment of keys to timbres in real time can produce extensions of the concept of the organ to a much fuller variety and flexibility of tone color. A simple example: if I am pressing two keys, I'll have the instrument sound timbres A and B, while if I press three keys at once, I'll have the instrument sound timbres B, C and D. In this way, the tone colors of the instrument can be made to vary during live performance in a way impossible on a conventional organ. And further, I change the character of my instrument by changing the algorithm.

Or turn to a different problem altogether: that of analysis and composition of music. Statistical methods can be used to analyze the probabilities of sequences of notes in

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some piece, capturing the composer's "style." These paramcters can then be used to generate sequences of notes "in the style of" that composer, yet constantly changing with time. Here we have used an algorithm to select and play notes, another example of one of the "algorithmic arts."

Some Parting Comments

We are all living in an exciting time of transition, as the wealth of computers and computer aided technologies permeates civilization. As I have noted, the effect of the growing availability of personal computing machines has the potential for significant influences upon art and science, influences achieved by the computing machine's action as an "intellectual amplifier" magnifying the effectiveness of one's thoughts through automation of well understood processes and coordinating actions and measurements with time resolutions impossible for humans. The new prospects for art and science are inherent in use of computers for what they are good for, on a wider scale then ever before, now that personal computing technology has become within the means of so many people. ■

This editorial was prepared as the text of a talk delivered on March 13 1978 during a session entitled "Creating with Calculators in the Classroom" at the American Chemical Society's 175th annual meeting in Anaheim CA.

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Department of Robotics Hocum

Notes by Carl Helmers

We have been hearing numerous reports of late concerning a reputed "robot" which would be sold for about $4000 and would be capable of household tasks from washing dishes to greeting guests. This particular "robot" has been seen in numerous general public media of late, including television and newspapers. Two (possibly independent) sources have confirmed how this allegedly artificially intelligent robot works. The first source to come to my attention was a newsletter called *Robot Builder No. 4* put out by Michael Westvig of 208 Via Colorin, Palos Verdes Estates CA 90274, which gives an account of the experiences of a group of individuals from the artificial intelligence laboratory of Carnegie-Mellon University, reported by Mark Fox and Brian Reid. The second source of information, confirming the reports of the newsletter, was a recent trip to the Massachusetts Institute of Technology Artificial Intelligence Laboratory. During that trip, which was a one day whirlwind tour arranged by Dan Hillis of the LOGO project, I was told of an ARPA Net file which has been accumulated on this "robot" by AI workers at laboratories around the country. The story on "Quasar" found in the ARPA Net file confirms the information in Michael Westvig's newsletter.

As a gizmo, there really is a "robot" travelling here and there for public entertainment. It has no mechanisms remotely capable of the grasping, sensing and manipulation needed to wash dishes or do other household chores. It has various mechanical systems for moving around, and — here is the hocum — a simple radio frequency link to *two* controlling human beings. One of the gentlemen responsible for operating the robot is the "voice" of the machine, carefully cupping the microphone in his hand while acting as a remote ventriloquist for the "robot's" voice. The second operator is a gentleman who, according to the *Robot Builder* account, keeps his hand in an airline flight bag which contains the controls for mechanical motions of the "robot." In short, don't get your hopes up that this is a real implementation of the independent robotic system concept of science fiction. As an entertainment and diversion it may be most acceptable, but an artificially intelligent robot it is not. The engineering technology is on the level of remote controlled model airplanes.

There is some legitimate concern by the people in the artificial intelligence community that the widespread electronic and printed media coverage of such a device may raise false expectations with respect to robot technology. I hope not. This "Quasar" carnival act may indeed have some positive effects by acting as a friendly publicist for the concept of the intelligent mechanism which is a real robot. If nothing else the public fascination generated by the extravagant claims of this "robot" will help demonstrate that a market for real automata at consumer prices will be present when engineering catches up with science fiction.■

Programming Quickies

BASIC Sorts

Rene E Pittet
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The world of personal computers is full of surprises at every turn for novices such as myself. Like a child discovering the world around me, I want to share my discoveries even with people who have already experienced them. My latest discovery is the ability of the 8 K BASIC supplied with my SwTPC-68 to perform sorts on numbers and words.

Listing 1 is a program for arranging a series of numbers into ascending order. Listing 2 is a similar program that arranges a series of words in alphabetical order.

The underlying strategy is the same for both programs. The alphabetic sort program gives each letter in the word a number. The individual letters are ranked in ascending order from A to Z. The entire word is then treated as one number.

In lines 110 to 170 of both programs the number of names or numbers to be sorted is read along with the data list which is stored in an array. Line 180 sets a flag to zero. A FOR. . .NEXT loop sorts through the list and determines which of the elements of each data pair is largest. If the second element is of lower rank than the first, the routine sidetracks the lower rank data momentarily into temporary storage place Z and the process is repeated until one pass through the data is completed. The flag at S is then checked. If S is equal to 1 another pass is necessary. If S is equal to 0 the routine will drop through to another FOR. . . NEXT loop in lines 290 to 310 where the list of numbers or words is printed out in ascending order.

Note that the order of the sort can be changed from ascending to descending by making the "greater than" test in line 210 a "less than" test. Also note that line 200 says repeat the loop four times rather than five times. This is due to the fact that line 210 looks ahead one step.■

Listing 1.

```
00100 PRINT"NUMBER SORTING"
00110 PRINT
00120 PRINT"HOW MANY NUMBERS TO BE SORTED?"
00130 INPUT N
00140 PRINT"INPUT NUMBERS ONE AT A TIME."
00150 FOR I=1 TO N
00160 INPUT X(I)
00170 NEXT I
00180 S=0
00190 N1=N-1
00200 FOR I=1 TO N1
00210 IF X(I) <= X(I+1) THEN 00260
00220 Z = X(I)
00230 X(I) = X(I+1)
00240 X(I+1) = Z
00250 S=1
00260 NEXT I
00270 IF S=1 THEN 00180
00280 PRINT
00290 FOR I=1 TO N
00300 PRINT X(I)
00310 NEXT I
00320 PRINT
00330 END
READY.
RNH


NUMBER SORTING

HOW MANY NUMBERS TO BE SORTED?
? 5
INPUT NUMBERS ONE AT A TIME.
? 27.8
? 11.5
? 55
? .98
? 33

 .98
 11.5
 27.8
 33
 55


SRU        0.467 UNTS.

RUN COMPLETE.
```

Listing 2.

```
00100 PRINT"NAME SORTING"
00110 PRINT
00120 PRINT"HOW MANY WORDS TO BE SORTED?"
00130 INPUT N
00140 PRINT"INPUT THE WORDS ONF AT A TIME."
00150 FOR I=1 TO N
00160 INPUT A$(I)
00170 NEXT I
00180 S=0
00190 N1=N-1
00200 FOR I=1 TO N1
00210 IF A$(I) <= A$(I+1) THEN 00260
00220 Z$=A$(I)
00230 A$(I) = A$(I+1)
00240 A$(I+1) =Z$
00250 S=1
00260 NEXT I
00270 IF S = 1 THEN 00180
00280 PRINT
00290 FOR I = 1 TO N
00300 PRINT A$(I);";";
00310 NEXT I
00320 PRINT
00330 STOP
READY.
RNH


NAME SORTING

HOW MANY WORDS TO BE SORTED?
? 5
INPUT THE WORDS ONE AT A TIME.
? RAY
? GINNY
? ROY
? JEANNE
? ROBERT

GINNY;JEANNE;RAY;ROBERT;ROY;

SRU        0.462 UNTS.

RUN COMPLETE.
```

Languages Forum

On Consumers' Languages and Standardization of Human Interfaces

Peter Mikes
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Dallas TX 75209

The suggestion of G A Taylor that a new standard is needed for the small appliance computers is timely. I do not share, however, his fear that BASIC or APL will become the Appliance Computer Language (ACL) used by the mass population. I believe that such a future ACL will be more simple than BASIC, more powerful than APL, and that without such a new and universal language the mass market in home computers will never beome a reality. I would like to share with you the experience on which I am basing that conclusion.

In the research and development division of a large corporation, I am handling application program designs which are too complex to be solved as a routine part of an engineer's work. Depending on the nature of the task, I implement the program with timeshare FORTRAN or APL or on a Tektronix Graphic System 4051 with only 16 K of memory in BASIC. These are special purpose interactive programs which are used typically for half a year and are used by "normal people." A normal person is concerned about the mechanical vibrations of a part which he designs. He is not concerned about dollar signs, differences between ⎕ and ⍞ and delimiters. When the program is verified I do sit down to the terminal with the future end user and witness how the simplest and most explicit instructions get misunderstood and confused by technically competent people.

The APL ranks highest in my experience as a medium in which the programs with good human interface can be written without generating an extra five pages of the code for each new command. APL accepts and executes most commands (niladic functions without result) when they are entered as basic input or as a response to a numerical quad. I would like to hear about another language which is that foolproof.

The APL (or Forth) is recursive, BASIC is as interpretative as APL but not recursive. The future ACL will be recursive and compilable by parts; it will respect the usual arithmetic priority and will have no large special character set. In particular, it will not call sin X, 1 O X and it will not say "syntax error" when you forget the right argument.

I don't think that such a language can be developed by volunteers. The group suggested by G A Taylor should be formed for the purpose of developing standards which are not only hardware independent, but to a degree language independent as well.

To give a concrete example from my own experience, I am familiar with two very high level systems called DIALOG and SCEPTRE: after the beginner learns that he must hit the return key to get any action, he comes to the cases where the clever programmer decided to save him that work by

requiring only Y or N answer. The return is then interpreted as zero answer to the next question.

There is no simple correlation built into the present languages between the types of prompts and types of legal answers. To the end user, such correspondence is all-important, particularly when applicable to all new computers.■

Concerning PASCAL: A Homebrew Compiler Project

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Your editorial in December 1977 BYTE was commendable. It served to reinforce my conviction that PASCAL is the next step up from BASIC for personal computing. As you and your readers know from the biographical sketch that preceded my article in November 1977 BYTE, a PASCAL compiler is my pet microcomputer project. Because that sketch prompted a number of inquiries about the status of my work, I thought a letter to BYTE would be timely following your editorial.

My approach to the compiler is to start with a small subset of PASCAL and add features as my resources and talents permit. I've begun by determining the minimum subset needed to describe its own compiler. Because statements written in the resulting language will still be valid PASCAL, the initial version can be debugged and run as a cross compiler on any computer which supports the full language. When operational, my compiler will convert itself to machine code to be loaded on the target microcomputer. Further development will be done on that machine. Each subsequent revision will be written in the PASCAL subset of the previous one.

At this writing, I have completed the parsing procedures and am testing them on a DECsystem 10 with the guidance of Dr Robert Mathis at Old Dominion University. The production of machine code is still some way off, because I feel I need more experience with the instruction set of the target machine, MOS Technology's 6502. I expected to get this experience with a

6502 based Challenger I ordered from Ohio Scientific in August, but it has yet to be delivered. Perhaps this spring I will have an operating compiler to report.

As an alternative to my subset approach, there is another way to implement PASCAL. It reflects upon your editorial discussion of the compiler/interpreter alternative. I am developing a pure compiler, but the standard PASCAL implementation is a hybrid. A program is available to convert source programs into assembly code for a hypothetical stack computer (HSC code). The assembled hypothetical stack machine code is then interpreted by the target machine. This technique has speeded implementation of PASCAL at several installations, and might be useful for personal computing since the hypothetical stack machine code is itself portable. A club, for example, might maintain the source to hypothetical stack machine compiler on one member's computer which had the necessary resources. Other members need only support the hypothetical stack machine assembler and interpreter for their machines. Although operationally more cumbersome than direct machine language compilation, this approach might speed up the availability of PASCAL and reduce the hardware requirement for applications users.

I know there are others around the world who are interested in PASCAL for their personal computers. I hope you will continue to provide a forum through which we may communicate.

Shortly before going to press BYTE received the following note from Stephen Smith:

My computer arrived shortly after I mailed this letter, 109 days after OSI confirmed my order.■

Languages Forum is a feature which is intended as an interactive dialog about the design and implementation of languages for personal computing. Statements and opinions submitted to this forum can be on any subject relevant to its purpose of fostering discussion and communication among BYTE readers on the subject of languages. We ask that all correspondents supply their full names and addresses to be printed with their commentaries. We also ask that correspondents supply their telephone numbers, which will be printed unless we are explicitly asked to omit them.

Technical Forum

Solving the Problems of International Television Standards

E John Dehaven
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Technical Forum is a feature intended as an interactive dialog on the technology of personal computing. The subject matter is open-ended, and the intent is to foster discussion and communication among readers of BYTE. We ask that all correspondents supply their full names and addresses to be printed with their commentaries. We also ask that correspondents supply their telephone numbers, which will be printed unless we are explicitly asked to omit them.

The following is a reply to Guy Burkhill's question in June 1977 BYTE, page 60, about use of 525 line video with English TV sets (presumably 625 line): I think I can help answer the question because I worked for some years with TV in a city that has *both* standards: Bangkok. In Bangkok there are three or four stations broadcasting with the US and Japanese CIRR standard (525 line, 60 fields per second, 2:1 interlace, 30 frames per second) and three or four using the German PAL standard (625 line, 50 fields per second, 2:1 interlace, 25 frames per second).

As you can imagine, there is a lot of business converting sets originally in one form or the other to work on both! If you are satisfied to stick with black and white, there is no problem at all. Nothing needs to be done!

I have seen hundreds of different kinds of TVs from all over the world and they would all receive both kinds of video transmission, and in most cases, a compromise setting of the vertical hold would cause them to lock on either signal. In the worst cases, a slight tweak of the vertical hold is all that is necessary. This is because the horizontal and vertical oscillators in TV sets are phase lock types that synchronize on sync signals that are part of the transmitted signal. Horizontal is no problem because the frequencies are nearly the same (625 x 25 = 15625, 525 x 30 = 15750) TV sets are never synchronized on the AC line because you might not be on the same generators as the TV station. The choice is made to make the vertical frequency match the line frequency in a given country so that any hum (line modulation) component that might creep into the video is stationary on the screen.

The only thing necessary to convert a black and white TV is to insert a ($2.00) 1 MHz oscillator-mixer module on the output of the video detector to convert the 4.5 MHz sound intermediate frequency (IF) to 5.5 MHz or vice versa, which would not be a consideration for a monitor application. This module was often installed with a switch so it could be turned on or off, but I have seen it installed without this switch many times and there was no noticeable deterioration of the picture caused by the presence of the extra sound subcarrier.

Here are some additional tips. You will experience 20% underscan. If this bugs you, adjust the vertical height control. Usually these controls (height and width) are set too high on a TV set anyway, since a customer is much more likely to be bugged by dark borders than he is by the loss of some of the picture.

All TVs contain various traps in the video IF, depending on the quality of the set. Almost all will have a sound IF trap

to trap out the sound subcarrier. I would suggest that these traps be removed (or switched out) for optimum use of a TV set as a video monitor.

If you are contemplating the use of color, you may be in some trouble. You should be very sure of just what you have in the way of signal before proceeding (see below). The two systems used in Bangkok have a color oscillator (phase locked again) that differs by some 800 kHz in the two systems. At the very minimum another converter is needed ahead of the color burst detector to get this oscillator in sync. If it is PAL, the phase alternating flip flop must be switched out ("red" signal). While successful color conversions have been made, it is very difficult to get everything right.

If you are not prepared to do a lot of tinkering with a color set, and do not have access to test equipment (good color generator and wideband scope at a minimum) your best bet would be to bite the bullet of customs and import a set from the US or Japan.

I do not presume to tell you what you have in your own country (Great Britain), but my reference (*ITT Handbook*, 5th edition) says that your standard is 405 lines/50 fields, 2:1 interlace rather than 625 lines. The sound carrier is AM rather than FM, according to this reference. Make sure of this before you buy a lot of expensive hardware!

It sounds like my remarks about black and white video would apply pretty much to your setup if it turns out to be this way in fact, except that the horizontal frequency would be 10,125 Hz which might be out of the range of adjustment of your horizontal oscillator without a little modification. These horizontal sync controls are typically built with a very wide range, though, so a TV set may be built to low standards of precision.

Under the 405 line system the video bandwidth is down to 3 MHz from the US 4.2 MHz. I don't know if this loss of resolution is tolerable, and what could be done about it would depend on the TV set. In some, it would be easy to take out traps and tweak the video IF a bit wider; in others it would be very difficult.

As to the other end of the conversion, I once converted a digital color generator (Heathkit) to generate both kinds of signals in use in Bangkok, and it was not too difficult at all, especially when you consider that the sync signals are not at a critical frequency. Get a schematic (send a couple of dollars and an explanation) from several manufacturers of TV interfaces and check out the possibilities. ■

Tick . . . Tick . . . Tick

. . . Booooom

W B Jazembski
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School of Medicine
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Lubbock TX 79409

Not all dangerous devices give nice little warning sounds. One such dangerous device may well be that small TV set that you are planning to use as a video monitor. All too many of the small TV sets being sold at bargain prices today are *not* line isolated devices. To the uninitiated this means that when you plug it into the wall, the AC power line is connected directly to the common reference or as you diehards call it, the "ground." In other words, the electrical reference connection within the TV set that you call the "ground" may be connected to the power line neutral (with its remote ground). *Or it may just as easily be connected to the "hot" side of the line, depending upon which way you plug it in.*

Where does the danger come in? If you connect your computer system to the TV set, the reference common on your system may well become lethally "hot" with 120 VAC. You may say that your system has worked for over a year with no trouble, so why worry. This is like carrying a small screwdriver in your pocket; it may take a year or more before it becomes wedged in the wrong way and punctures your skin when you bend over. In like manner, the "hot" chassis syndrome may exist for many moons before you acidentally find that you have one hand on a ground when you touch the chassis of your computer system with your other hand. (The radio industry produced "hot chassis" cheapies for months before a number of fatalities forced the change to complete isolation. You will note that the inexpensive TV sets do not have a conventional metal chassis except for the tuner and that there are no openings in the case to poke a screwdriver into.)

Even if you are the only one who touches your homebrew computer, you may forget sometime and touch metal and ground simultaneously. Or, you may have a young visitor who has not yet learned the dangers of knob twirling and switch pushing. Oops, there goes a neighbor's kid, and he was one of the nice ones.

For computer manufacturers: Remember you will be held responsible for such acci-

dents unless you have made it quite clear that only persons expert in the field should attempt to interface to a TV set without being absolutely certain of the type of TV set they are dealing with. Check with your lawyer and see just how responsible you are in light of the current wave of product liability laws and litigation.

Oh yes, for you hardy homebrew souls who still wish to proceed with the small TV set, there are several solutions that may be used to use that $79 set that you bought for your home computer. Probably the easiest to understand and implement is to purchase a small line isolation transformer from your friendly electronics supply house and install it between your TV set and the power line.■

Avoid Self-Modifying Code

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Concerning the Programming Quickie in July 1977 BYTE, page 166, by Gregory Worth, I would like to make a comment. The timing subroutine as shown is similar to one I've been using for some time. However, Mr Worth's version has a potential problem which is rooted in the fact that the routine employs what is commonly referred to as "self-modifying code." It is best to avoid such tactics, especially when the task can be accomplished equally well without self-modifying code. The offending instructions appear in the listing at hexadecimal address 0006 and 0009. These instructions actually change the instruction at location 0003 from LDX # C350 to something else (depending on the state of the carry) and back again. If the user applies a reset at the right time (or, wrong time as the case may be) the instruction at 0003 will be left in the garbaged state. For the same reason the code is not reentrant.

The fix is simple. All Mr Worth needs is six bytes of code that take 12 cycles total to execute. This can be accomplished several ways including six 1 byte, 2 cycle instructions such as NOP, CLV, SEV, CLC, or SEC; three 2 byte, 4 cycle instructions such as CPX LOOP2; or two 3 byte, 6 cycle instructions such as TST LOOP2. All of the above instruction sequences will have the same effect as the two offending instructions, except that they don't change any memory locations.■

Book Reviews

Scientific and Engineering Problem Solving with the Computer
by William Ralph Bennett Jr
Prentice-Hall, Englewood Cliffs NJ 07632
457 pages, 8½ by 11 inches
$17.95

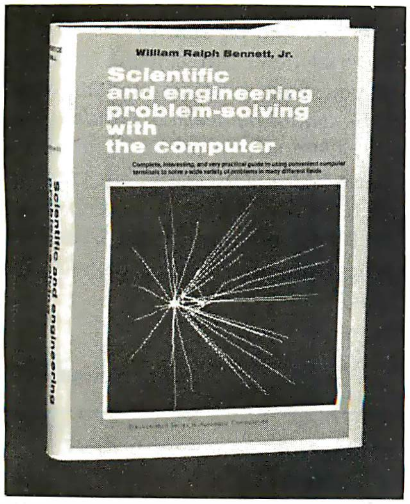
Reviewing this book is not unlike the task C K Ogden set himself in the *Saturday Review* when he reviewed the *Encyclopedia Britannica.* William Ralph Bennett's *Scientific and Engineering Problem Solving with the Computer* will appeal at once to the computer scientist, physicist, artist, electrical engineer, musician, and linguist, to name but a few of the disciplines covered. It is massive in size and scope.

The book grew out of Prof Bennett's highly praised course, "The Computer as a Research Tool," given at Yale University. Its structure, in the author's words, is based on the belief that "the best way to teach students computational methods is to give them lots of interesting problems of gradually increasing difficulty." The BASIC language is used throughout the book because the author feels it is easily learned and is conversational in tone.

Rarely has such a diversity of material been covered with this much rigor, elegance, and wit. Prof Bennett is a polymath with a vengeance: here you'll find topics ranging from pattern recognition to Poe's cryptograms; from falling bodies to Fourier series; from entropy to electric fields; not to mention rocket travel; the diffusion of disease; the Dolby system of noise reduction; lasers; hieroglyphic decoding; the sailor-prostitute problem; cyclotrons; Taylor series; economics and matrix inversion; contour plots; nonlinear distortion in magnetic tape recording; Van Allen belts; solar flares; the Roger Bacon cypher; and on and on (that's less than a fifth of the subjects listed in the table of contents).

Every subject is covered in depth, and real, practical algorithms and example programs are given (in some cases for the first time). For example, in chapter 4, which deals with language, the author states his intent to lure humanity majors into the world of computers. The chapter begins with a description of the classic idea of the monkeys and the typewriters, in which an army of monkeys typing at random would eventually type out all of the world's great literature.

This leads naturally to a discussion of



random processes, Eddington's conjectures about the random motion of gas molecules, some first order monkeys, a few BASIC correlation matrix programs — and the unsuspecting humanities student is hooked (along with the rest of us)! Nor does Prof Bennett stop there, for next is a discussion of second and third order monkeys, the Eddington baboon, Markov processes applied to music, entropy in language, and this typical exercise:

> Using the algorithm in the text with the pair-correlation matrix from *Hamlet,* compute the most probable diagram path which starts with the letter T. Compare the result with that given above for Poe's *The Gold Bug.*

I particularly enjoyed chapters 7 and 8, which cover Fourier series and electronics. Here you will find elegant programs designed to teach the theory of vibrating strings, the design of filters, and the fast Fourier transform. This is one of the exercises:

> Write a program to generate fake data for the plucked string example. Use the method of least squares fit to extract "best fit" parameters for the amplitude, decay rate and frequency. . .

An intriguing feature of the book is the wealth of excellent, unusual illustrations (page 346 depicts Michelson's incredible spectrum analyzer machine built in 1903). Physicists will enjoy thumbing through it for this feature and for the careful exposition of physics in a computer science context.

The book contains a complete introduction to BASIC for readers new to the language. Anyone with a good grounding

Circle 81 on inquiry card.

in algebra should be able to absorb most of the material here, but calculus is a definite plus if you want to tackle the later chapters. *Scientific and Engineering Problem Solving with the Computer* is primarily an idea book that reads like a good novel, but satisfies like a good textbook. I intend to keep it nearby in case I have to design a laser or analyze the syntactic structure of the Greek Decree Of Canopus.

You never know.

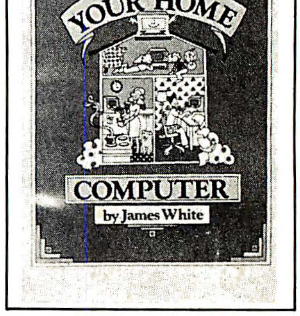
Chris Morgan, Editor ■

Your Home Computer
by James White
DYMAX, Menlo Park CA 94025
235 pages, softbound
$6

This book is a good introduction to personal computing for the reader with little or no technical background or experience with computers. It is particularly strong in its hints for evaluating and buying a personal computer and its suggestions for home applications.

The book begins with a brief introduction to the concepts underlying computers, including the semiconductor technology which has brought computer prices down to an affordable level. This is followed by an introduction to microprocessors, types of memory, and microcomputer peripherals. Photos of some of the popular micro products are included as examples. The book concentrates on the concepts and the factors for evaluation which should be considered by the prospective microcomputer buyer.

The most interesting section of the book offers advice on how to get started with personal computers, commenting on microcomputer manufacturers and mail order vendors ("cash now, delivery later"), computer stores, the hazards of kit building, and the differences between single board computer "trainers" and full-scale micro-



Circle 99 on inquiry card.

computers. A very brief introduction to programming is included as well. The author suggests an evaluation scheme for "system selection by weighted factors."

The final section of the book describes a wide range of home computer applications. Cursory discussions are offered on educational applications, amateur radio, electric trains, robots, electronic music and art, games, financial record keeping, stock market analysis, a kitchen inventory system, word processing and home environment control. A chapter entitled "Inventions Wanted" encourages the reader to try out his or her own innovative ideas.

Appendices provide useful, though necessarily incomplete, lists of names and addresses of manufacturers, personal computing periodicals, computer clubs and computer stores, as well as a table for the ASCII character set.

My only complaint is that the book doesn't devote much attention to software concepts. I believe that these can be approached on the same nontechnical level as the book's discussion of hardware concepts, and that an understanding of a computer's software features (from the user's point of view) is crucial to an intelligent purchase decision. Nevertheless, the book should prove very useful to anyone wishing to get started in the field of personal computing.

Dan Fylstra
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Boston MA 02134■

Publisher's Note. . .

Concerning Reprints from BYTE

Readers are advised that through error on our part in coordinating selections of material for outside reprints of past materials from BYTE, there is a significant overlap of content between *The Best of BYTE Volume 1* published by Creative Computing Press, and *The Scelbi/BYTE Primer* published by Scelbi Computer Consulting Inc.

We do not advise purchase of *both* volumes by readers without comparing their respective tables of contents side by side, among friends or in a local computer store. After discovering this problem, we have taken the only step possible for us: There will be no second printing of *The Best of BYTE Volume 1* now that the first press run is nearly exhausted.

Virginia P Londner
Publisher

Clubs and Newsletters

North Florida Computer Society

The computer enthusiasts of Pensacola FL have formed an organization for all interested people called the North Florida Computer Society. They meet on the second Thursday of the month. For more information write to Eugene Rhodes, 227 Edison Dr, Pensacola FL 32505.

For Computerized Hams. . .AMRAD

The Amateur Radio Research and Development Corporation is a Virginia based group which has been operating for three years. AMRAD's membership has grown from 28 at the end of 1975 to 90 at the end of 1976, to 200 at the end of 1977.

For more information concerning the club, write to the Amateur Radio Research and Development Corporation, 1524 Springvale Av, McLean VA 22101.

Tennessee Computer Fair Scheduled for May

The Computer Club of Walters State Community College, Morristown TN, is sponsoring the First Annual Computer Fair of East Tennessee to be held May 3 1978 from 10 AM to 8 PM on the college campus. Admission will be free. A variety of computer equipment will be on display, illustrating applications in education, business and the home.

There will be a charge of $15 for those wishing to exhibit at the fair. The money will be used to establish a scholarship fund in computer science. For more information, contact William R Parks at Walters State Community College, Morristown TN 37814, (615) 581-2121.

Space Coast Microcomputer Club

The Space Coast Microcomputer Club newsletter, the *Enterprise,* has a rather eye-catching cover design. Edited by Mike Rodby (also club secretary), it contains statements from club officials, articles from members, and a variety of computer related material. Write to the Space Coast Microcomputer Club, 219A Fillmore, Cape Canaveral FL 32920.

Birmingham AL Amateur Radio Club

The Birmingham AL Amateur Radio Club and the Birmingham Microprocessor Group will sponsor the "BirmingHAMfest '78," May 13 and 14, at the new air-conditioned Birmingham-Jefferson Civic Center. There will be numerous exhibits and forums on microcomputers, amateur radio and related areas, and a flea market. For more information, write BirmingHAMfest Information, POB 603, Birmingham AL 35201.

On Line

On Line is a medium through which computer experimenters can swap and sell equipment, programs and services related to the field of home and business computers. For information concerning advertising rates or subscriptions, write to *On Line,* D H Beetle, Publisher, 24695 Santa Cruz Hwy, Los Gatos CA 95030.

Homebrew Computer Club

This organization's newsletter contains many good articles covering the experimenter's world. For a subscription or more club information, contact Homebrew Computer Club Newsletter, POB 626, Mountain View CA 94042.

NECS

The New England Computer Society located in Bedford MA holds informal meetings dedicated to the TRS-80 and COSMAC VIP, as well as software demonstrations. For further information contact the New England Computer Society, POB 198, Bedford MA 01730.

Long Island Computer Association (LICA)

LICA is now well into its third year of existence, and has two active special interest groups: one for the 8080 (which has been running up the phone bill with three computers now operating modems), and one for the 6800. There is also a class on computer construction held monthly before the regular meetings and conducted by Al Harrison. For more information, contact LICA, 28 Splittrail Pl, Commack NY 11725.

Houston Amateur Microcomputer Club (HAuCC)

For information concerning membership, meetings and the like, write to HAuCC, POB 37102, Houston TX 77036. ■

Continued from page 24

One out-of-context quote was seized upon by editor Morgan as an error, thereby drawing my attention to a possibility not explored by the authors. The command "Compute to the last digit the value of pi" was issued *because* it is impossible to fulfill. The computer had been invaded by an evil disembodied entity which effectively became the consciousness of the computer. When Commander Spock's little trick tied up the entire system, the entity fled.

The fact that a conscious being could inhabit a computer in so integral a fashion may imply that the "computer" of Star Trek's time is based on an entirely new, indeed unfathomable, technology. (I say "may" because to the best of my knowledge no one has yet attempted to inhabit a Z-80.) One possibility which suggests itself is that the device is at least partly organic. (Blish's adaption of the episode "Miri" features a portable cat-brain computer not mentioned in the television version.) Such a development would probably lend itself very nicely to speech recognition and natural language processing.

Carol J Pruitt
1134 Summit Av SW
Cedar Rapids IA 52404

GIZ-WIDGETS

I have just read the response to reader Salas's letter in January 1978 BYTE, and must disagree with one statement: "Where tracing or debugging of read only memory software is involved, the simulator technique is the only one which will work, since breakpoints cannot be set in read only memory." A very elegant hardware debugging method exists that is useful for code obtained from *any* source (read only memory, programmable memory, fast cache, or whatever). In fact, one of your advertisers, Micronics, offers just such a device.

Conceptually, such a device is fairly simple. Assuming that your processor(s) is (are) interruptible, connect the interrupt line to a logical comparator whose inputs are from digit switches on one side, and the address bus on the other. Whenever the address that you have dialed into the digit switches appears on the bus, an interrupt is generated, sending the processor to a routine that you have already placed in memory. This routine does whatever housekeeping is necessary, and does a register dump for the operator. This scheme has numerous capabilities: for example, if you are trying to find out why memory location XYZ keeps getting clobbered, you can dial in the address of XYZ. Then, when XYZ is accessed for write, the breakpoint system generates an interrupt and flags the current PC for you. Now you know where to go looking in your program for the troublesome code. Note that a little ingenuity will allow conditional breaks, where the conditions can be the contents of some register, a switch controlled by the operator, read status, write status, fetch status, or anything else you might imagine can be used as a condition. Either the condition itself, or the combination of the condition and the address bus state, can be used as the interrupt signal.

If you don't have an interruptible system, there is still hope. Connect the comparator's output to a latch, and connect the latch to the system's HALT line. When the machine stops, the pertinent data can be read from the bus display.

It should be clear that my approach to solving computing problems is with hardware, not with cumbersome and potentially very expensive software. I find that $10 worth of components will usually do the work of a routine that took a week to code, debug and document. Of course my solutions tend to be permanent in existence. I have a whole shelf full of little giz-widgets that were built on the spot to solve a particular problem, performed their function, and found their way onto the shelf as reminders of times past. But the price is right, and I will keep on using the method that gets results for me.

By the way, I can't say exactly what the capabilities of the Micronics system are — I don't have one because it won't plug into my 6800 based system. But from the way their ad reads, it will do everything you want for a debugging tool.

As a closing note on a different subject, I find your January 1978 feature article by Kent to be fantastic! I am looking forward to more! Keep up the good work.

Bob Hale
POB 616
Rancho Santa Fe CA 92067

It all depends on your point of view. The ordinary processor, without a hardware aid such as you propose, will still prove impossible to trace through read only memory using breakpoints. Many of us find a logical shelf full of software giz-widgets doing jobs similar to your quick hardware tools.

MORE AI WANTED

I have read Michael Wimble's 2 part article on artificial intelligence in May and June 1977 BYTE and found it interesting and informative. Please include more articles on AI as the details of implementation are not widely known or understood, and examples would go a long way to getting the hobbyist started in this fascinating field.

Robert Graves
21175 Goldsmith
Farmington Hills MI 48024

THANKS FOR CALCULATOR ARTICLES

As a member of the SR-52 Users' Club, 9459 Taylorsville Rd, Dayton OH 45424, I was very glad to read "How to Write an Application Program" by William B Jenkins (October 1977 BYTE, page 18), featuring the Texas Instruments SR-52 programmable calculator. I hope that you have more articles like this, as it seems to me that the programmable calculator does not get the publicity it deserves.

David W Johnston
POB 3781
Washington DC 20007

KIM NOTES

Hal Chamberlin's article "A Sampling of Techniques for Computer Performance of Music" in September 1977 BYTE has provided a lot of good information to say nothing of good music from KIM. Many people around here have been surprised and pleased at the sound — an excellent article.

I would like to point out that the voice pointers (V1PT thru V4PT) point *not* at the waveform tables as they should, but at location 0000, which means that the program uses itself as the waveform table . . . making a rather horrible sound indeed, and leading one to believe that the filter is inoperative.

An interesting "song" can be heard if one changes the song pointer (SONGA) to point to the program itself, or even to the KIM's built-in programs in read only memory.

Hugh C Holland
500 W Main St
Endicott NY 13760

The comment statements in listing 2 (page 72) and the main text both indicate that the four voice pointers point to the waveform table, table 5, page 79. We should have stated this explicitly in the caption for listing 2. We apologize to Mr Holland and to other readers who may have been confused by this point. . .CM

PC ARTWORK SERVICE NEEDED

I have invested considerable money in artwork and drafting aids for twice actual size printed circuit layouts. I have been using this method for six years now, but my contact in the photography business can no longer do my photoreduction or plastic masks.

I wonder if any of my fellow BYTE readers know of a firm willing to do small jobs of this type? If someone does, please contact me.

Brian Beard
PSC Box 1755
MacDill AFB
FL 33608

RIBBONS FOR THE SwTPC PR-40 PRINTER

Some time ago the systems design department of this university bought a PR-40 printer from SwTPC for use with the several SOL-20s used in our control systems lab. Naturally a new ribbon became necessary after a time and, logically, it made sense to obtain it through our normal suppliers of such basic items. The problem, as I soon found, lay in finding a manufacturer's part number for the ribbon, a detail not found in any of the documentation.

After some false starts I called the manufacturer of the print mechanism, LRC Inc in Riverton WY. About one minute later I was in possession of chapter and verse. Efficient, fast and courteous service was a very refreshing change.

For the information of PR-40 users, the correct ribbon is Addressograph-Multigraph Graphics P/N 116-2395-326.

John G Wilson, Systems Analyst
Faculty of Engineering Systems Design
University of Waterloo
Waterloo, Ontario CANADA N2L 3G1

BUBBLES HAVEN'T BURST ON THE SCENE?

What happened to the TBM0103 bubble memories you said would hit the market last fall as subsystems of mass storage? Your comments were made in the July 1977 BYTE editorial, "This Elephant Never Forgets," by Carl Helmers.

John Herscher
2105 Independence Av
Kansas City MO 64124

Texas Instruments markets a whole line of new terminal products which incorporate this memory part. These have been seen in the marketplace of commercial equipment since introduction at the NCC show last summer. Apparently most of the TI production is being used internally for their own products, rather than being sold to other manufacturers for incorporation into end user equipment. But this is no doubt a temporary condition, for TI is hardly about to ignore its traditional components markets for parts.

A SUGGESTION FROM EREWHON...

Prof Kent's article "Biological Model for Robotics" in January 1978 BYTE was interesting and the best presentation for the layman I've seen.

I've been interested for a long time in trying to devise ways of imitating any kind of biological brain and while at the Michelson Labs in 1964, built a few electronic neurons from discrete components using the cordwood concept. The volume was still 1½ cubic inches, which I calculated would require the entire 3 story lab building to house the brain of a small bug. Since I had no funding I gave up that idea.

Later in 1967, while head of the Fluidics Lab at Genge, I built some neurons using fluidic logic and amplifiers, as well as matching power amplifiers and even solid state fluidic powered muscles. The neurons were reduced to about a tenth of a cubic inch, but the power supply problem was insurmountable, and the cost for a brain of any complexity came in at about $100 million for components alone.

I have given up on the concept of duplicating biological mechanisms with electronics and fluidics primarily because I have discovered a neat way to duplicate brains for about $10,000 each, and the beauty of it is that almost any hobbyist can do it providing (s)he gets the appropriate state licenses.

My partner and I made two of them, which turned out pretty well except for a few minor aberrations which a friend at UC Santa Barbara assured me would clear up in a few more years.

This method has a very high yield; less than one serious malfunction in 100,000 brains, which is a lot better than the silicon chip guys can do.

The only trouble with these brains is that it is difficult to achieve specific characteristics in the finished product, and the housing they come in is not suitable for harsh environments. Of course the real problem is that after about 18 years, these androids run off, and since you can't tell them from humans at that age, the society grants them human status and you can't get them back.

I feel that the best way to make brains is to do a little genetic engineering on existing life forms and then maybe you could grow them faster with better control over parameters and at considerably lower cost. While you're at it, you can redesign the housing and program them so they won't run off.

Right now I'm waiting for the fellows at the lab to get the genetic engineering down pat so a guy can fool around in his home lab and make his own brain. In the meantime, I'm sticking to my old PDP-8L for strictly digital applications.

John F Cogger, President
Cogent Inc
1605 Morse Av
Ventura CA 93003

IN THIS READER'S OPINION BOMB BOMBS?

Your BOMB questionnaire is improperly structured for a nonbiased sampling of the true feelings of your readers towards the articles in question.

The causes of this bias are the result of several specific problems, the first of which is the physical layout of the questionnaire. By giving the questionnaire more answers in the good to WOW range than in fair to poor rate, you have biased your answer towards the good to very good answers. You could probably give the questionnaire to 100 people who have never heard of your magazine and get a preponderance of good to very good rather than the normal distribution of answers around the fair answer which would be the normally expected result.

The second problem results from the very nature of questionnaires, ie: what relationship does your sample (the readers who returned the cards at their own expense) have to your readership as a whole. The answer is probably very little.

Let us examine the typical responder. First, he (or she) must be extremely self-motivated, merely because he (or she) is interested in an unusual, expensive and technical hobby. The responder would be of above average intelligence and must be motivated enough to pay $.13 to tell you how he (or she) feels about an article.

This last point bears further examination. In response to prepaid questionnaires, the response rate is at best 10% to 20%; the response to questionnaires that are not prepaid is typically one to two orders of magnitude less.

Thus by skewing the expected distribution of answers toward favorable replies by questionnaire structure, by the nature of your sample universe (your readership would tend to be of above average intelligence, extremely self-motivated and as a result tend to very opinionated) and by requiring positive action (putting the stamp on the card) to respond to the questionnaire, you will have gotten an extremely small, biased sample of an extremely large data base.

It's your survey to run, but you should realize that in my opinion your statistical model has little resemblance to reality.

John W Simpson Jr
Box 13062
Pittsburgh PA 15243

We have no pretension that the BOMB voting represents an unbiased sample. Its prime purpose is editorial feedback from readers. If no one sent in the cards, we would assume (being optimists) that everything was "right" with an issue, in so far as readers are concerned, a possibly dangerous assumption. But cards always come in. BOMB gives us a structured form of feedback with a monthly sampling of those

readers who are "intelligent" and "self-motivated" enough to express an opinion by both the circled ratings and the comments scrawled across the bottom of perhaps 20% to 50% of the cards.

From a functional point of view, the design of the form and the requirement of a thirteen cent stamp act as a filter to limit the responses to the "opinionated." The analysis would be intractable on a monthly basis if this were not the design. The key items are that BOMB provides both verbal commentary and an algorithm for numerically evaluating in some sense "what the readers think" of the authors in an issue. The reality in question is in the responses themselves, not in some alleged statistical model. . .CH

COGNITION AND ROBOTS

I feel there is a tendency among people in the field of artificial intelligence to give their work false prestige by using the terminology of consciousness to talk about machines. The confusion that exists these days, even among computer professionals, about the difference between computation and thought is so great that the terms should not be thrown around this way.

To state that difference briefly: the concept of computation is logically dependent upon, and derives from, the concept of thought. When you are faced with a new problem, you explore various ways of solving it, possibly coming up with new cognitive methods in the process. Once you have enough experience with a certain class of problems, you can put a method of solving them into words which are so explicit that no further thought is needed to follow them; you just carry out the procedure. But this is something you can only do after having completely solved that class of problems, in pattern. For instance, to solve an arithmetic problem, you can just apply the appropriate rules. The only mental effort required is the effort of remembering the rules, and possibly some of the intermediate results.

Computing became more significant when people realized they didn't have to carry out this mechanical rule following by themselves. They could design machines which would perform computations for them, given an appropriate encoding of the necessary data. But these machines could not solve any problem until someone had thought out the method of solving it and turned it into an explicit procedure. This is a restriction on computation as such, and hasn't been relieved by any technical improvements; nor can it be. The key to computation is the elimination of all thinking from a procedure. This applies to learning and heuristic programs as much as to any others; these programs simply perform computations to generate other computational rules or trial results.

I believe that robots do not have "senses" and do not "perceive." Sense perception is the function of providing raw data about the world to a conscious being. If you remove this differentiating condition, then anything that affects something from without might as well be called a perception. The only difference between a robot's "perception" of light by photodiodes and a rubber ball's "perception" of a wall when it bounces is a difference of medium and of complexity. Treating the concept this way renders it meaningless.

Nor is possessing a model of one's environment the same as having knowledge. Knowledge is the sum of a conscious being's identifications of reality through sense perception and through the development of concepts from these perceptions. The idea that knowledge isn't awareness of what's "out there" by firsthand means, but rather a structure "in here" which (if you're lucky) has some sort of correspondence to the outside reality, is just a modernized version of Kant's phenomenal world."

If we are going to avoid giving people science fictionish fears of robots that have minds of their own, we should avoid misleading terminology.

Gary McGath
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Nashua NH 03060

COMMENTS: TRANSIENTS

I have just read the article entitled "Spikes: Pesky Voltage Transients and How to Minimize Their Effects," as published in November 1977 BYTE. I would like to take this opportunity to update the readers of BYTE on the state of the art concerning your solution to the transient problem.

We have been involved in the research and development of transient voltage suppression devices for several years and now feel obligated to alert everyone to the potential hazard of varistors in the application you describe. As a manufacturer of transient voltage suppressors we discarded the varistor a number of years ago because it will age, and aging increases the leakage current. The higher the current, the faster the aging — a runaway condition. The higher the ambient temperature, the sooner this can happen. A runaway condition might be a fire hazard. The varistor has its place in the proper environment, but its application must be carefully chosen.

As a manufacturer of transient voltage suppressors, we have marketed a 110 V "plug-in" unit that is extremely effective without the use of a varistor, at a cost that is comparable to the circuit you describe. If you would like additional information concerning our product, please feel free to contact me personally.

Stephen J Sorger, Vice President
W N Phillips Inc
356 Bacon St
Lake City MI 49651 ■

BYTE's Bits

National Computer Conference Gets Personal

Anaheim CA is the site of the 1978 National Computer Conference (NCC) to be held June 6 thru 8 at the Disneyland Hotel Convention Center. Featured at the show will be a Personal Computing Festival, which quickly became one of the most popular attractions at last year's NCC.

Major events scheduled for the Festival include an exhibit of personal computing products and services, a program of papers and presentations, and a display of individually designed personal computing systems and applications. Commercial organizations will display microcomputer systems, kits, components, terminals, floppy disks, cassette tape systems, and software in the Exhibition Hall.

A special program of papers and presentations relevant to personal computing is to be presented; a softbound volume, *Festival '78*, will contain the collection of these presentations and will be available during the Festival. Approximately 30 sessions are planned, covering such topics as graphics, music systems, speech synthesis, computer games, personal computers for the handicapped, small business sytems, software design, microprogramming, optical scanning, floppy disk systems, seminars for club leaders, hardware and software standards, and many more.

Individuals will have a chance to display their own personal computing projects and compete for prizes.

Main Show Activities

Not to be outdone, the main show at the National Computer Conference will feature over 330 organizations at 1,382 booths showing everything from minicomputers to multimillion dollar systems. Software systems, test equipment, peripherals, education, and training materials are just a few of the items to be seen. More than 4,000 industry representatives will be available at the show to demonstrate products and answer questions.

There will be over 100 technical sessions dealing with systems, methodology, applications, and management issues. Time will be allocated for presentations based on outstanding papers delivered at recent specialized conferences and workshops, and—of particular interest to personal computer enthusiasts—a number of sessions will be devoted to microcomputer applications and design. Conservation of energy and allocation of resources are two of the topics to be discussed. Computer systems sessions will cover data networks, distributed systems, programming and operating systems, plus computer architecture and the impact of recent developments on hardware technology.

Conference Call

Conference registration for NCC 78 includes corresponding admission to the Personal Computing Festival. For students, experimenters, and others not planning to attend the NCC main conference, separate one day and three day registrations will be available for $5 and $9, respectively.

Approximately 25,000 people attended last year's NCC Personal Computing Festival; conference officials hope to surpass this figure by a comfortable margin. Attending the NCC last year proved to be fruitful for us: the sheer variety as well as quality of the offerings was exciting and thought provoking. We look forward to the same high quality this year. . .CM■

Picking the Right Color Television for an Apple, Continued

In the review of the Apple II published last month (page 18), I noted problems with the display achieved using a Panasonic color television. In that writing I stated that Apple Computer recommends use of Sony color televisions due to their superior shielding from extraneous radio frequencies. I tested that recommendation by going to a local shopping mall and purchasing a 19 inch diagonal Sony "portable" television which lists for about $600 currently. When this television is used with the Apple II instead of the 13 inch Panasonic, all traces of instability and RF interference are gone when the Apple II drives the television on channel 3 using a modulator.

However, there is a problem which still remains: when the television is looking at channels 2, 4 and 5 broadcast from Boston MA (perhaps 75 miles line of sight) through a rusty derelict of an

outside antenna which came with my house, I pick up noticeable herringbones from my homebrew computer system in the basement—and when the Apple II is on, the herringbone pattern picked up by the antenna lead running next to the Apple II is even stronger. So users of personal computers who live in fringe areas with respect to television reception are advised to sign up for the local cable company, or be careful to run antenna leads far away from the computer. This problem is hardly confined to any one design, and I would expect that any personal computer delivered in unshielded packaging would have some television interference problems due to the high frequency components present in typical digital signals. . .CH■

Call for Abstracts

A call for abstracts has been issued for the Software Quality Assurance Workshop: Functional and Performance Issues, to be held in San Diego CA on November 15, 16 and 17 1978.

Cosponsored by the Los Angeles Chapter and National ACM (SIGMETRICS and SIGSOFT), the workshop is concerned with current developments and experiences in assuring software quality. In this context quality means software meeting specifications and requirements in both operation and performance. Since software quality cannot be tested into a software product after it has been completed, the effort to assure quality must surround the product throughout its development cycle. As a result, software quality assurance issues include: procedures for functional and design reviews; tools and procedures for controlling, testing, debugging, and assessing adherence to standards and conventions; and final product acceptance testing. Abstracts on experiences (successes or failures) are welcome. Topics may include: quality assurance tools, configuration management, performance measures, reporting systems, software library control systems, system auditability, performance evaluation, technology tradeoffs, methodologies, standards development, and testing techniques and tools.

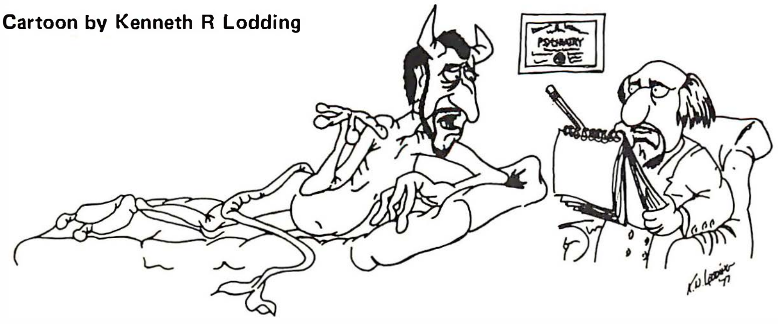
The computer system base for these tools or procedures may include the full range from microcomputer to large systems. Interested parties are invited to submit ten copies of a detailed abstract to the program chairman, Clint Woodworth, Clinton Woodworth Associates, 150 Lagunita Dr, Soquel CA 95073.

All submissions will be read by the program committee and evaluated on the basis of significance, relevance to the workshop purpose, and overall quality. It is important that the abstract convey the ideas and contain enough information to enable the program committee to determine the scope of the work. Given the time constraints, the abstract should be limited to no more than five double spaced pages. The author's name and affiliation should appear only on a cover sheet attached to one copy of the abstract for use by the program committee chairman.

The deadline for submission of abstracts is April 15 1978. Authors will be notified of acceptance or rejection by June 10 1978. The authors of accepted abstracts must submit their manuscripts to the program chairman, typed according to specifications, by September 10 1978. In addition, these authors should prepare verbal presentations for part of the workshop program itself.

For additional information about this workshop, contact A C (Toni) Shetler, general chairman, Xerox Corporation A3-49, 701 S Aviation Blvd, El Segundo CA 90245. Proceedings for this workshop will appear in a special issue of the SIGMETRICS *Performance Evaluation Review* and will be distributed at the conference.■

Cartoon by Kenneth R Lodding



"Does he want booze? Money? Girls? No, he *wants a 1000 lines of error free code."*

This is the third and final part of Mike Wilber's series on the design for the CIE Net. Readers should refer to part 2, figures 1 to 5, for BNF expressions of the protocols referenced in this last segment. In this article we continue the figures and listing sequence numbers from the previous part.

CIE Net: A Design for a Network

Mike Wilber
920 Dennis Dr
Palo Alto CA 94303

Protocol Levels and Parameter Lines

The formats of interstation transmissions and end-to-end messages include protocol level numbers and parameter lines in order to make the formats identify themselves. The intent is that these identifications change whenever the format changes sufficiently to invalidate a program that would have to understand the format. The protocol level numbers are just that, but the end-to-end messages also contain parameter lines that can more easily show fine shades of meaning. For example, the parameter line describing text compression might name the compression algorithm being used and also give some initial settings for its state variables.

The rest of this specification says nothing about particular choices of values to be inserted for protocol level numbers and parameter lines, but some (arbitrary) choices should be taken. For the sake of definiteness, we can arbitrarily pick the number one to be used for the <protocol number> in both the interstation and end-to-end protocols. The parameter lines used for the <compressed tail> and the <file tail> can be arbitrarily picked (for example, with my initials, giving "BMW 1") in order to leave room for expansion.

Flow Control and Congestion

One of the most embarrassing questions you could ask me now would be something like, "How do we convince the poor people in Denver that they are interested when all the traffic from one coast funnels through them before spreading out to the other coast?" I don't have any good answers to any such question. The whole problem is helped somewhat by the voluntary nature of the network: a relay station can stop taking traffic from a CIE when its buffer storage gets filled up. (Note that that forces the CIE to (somehow) decide which of its traffic is the most urgent.) It's also helped somewhat by the fact that transcontinental telephone calls get very cheap late at night, and so a single long hop becomes much cheaper than many short hops.

Flow control is included at the interstation level, but is absent at the end-to-end level. The reason for the omission is simply that the transmission is so highly buffered that the source CIE is out of the picture long before the destination CIE is contacted. Any CIE or relay station along the route can simply refuse to accept more traffic than it can handle (perhaps returning a negative acknowledgment), but the entire flow control question needs far more thought than I've given it so far.

Legal Aspects

There are a couple of legal aspects that deserve mention, even though I am not in a position to say anything very decisive about them. The first is a big unknown to me: there may be states (or whole regions) where the telephone company has tariffs preventing private individuals from using personal telephones for data transmission. (The same may also be true of whole countries that might want to put up a network

of Community Information Exchanges

Part 3: Other Considerations

something like a CIE Net.) I am unfamiliar with the laws and regulations covering private telephone usage in all locations, and such regulations could be a real impediment to any sort of grass roots computer telecommunication network.

The other area is one on which I can be slightly more conclusive: regulatory hassles. At least in the US, coming under the regulatory agencies can consume vast amounts of time and money. Communication is a field of endeavor that is subject to regulation, but that only seems to be a real problem when money changes hands. Even when money changes hands, though, the regulatory agencies seem happy to let you go relatively unperturbed if you can convince them that nobody is making a profit.

A Universal Language

A CIE Net would need a universal language if messages are to be effectively transmitted throughout a large, diverse and only loosely organized community of stations providing transmission and buffering services. A universal language is especially imperative because of a very important characteristic of the routing algorithm I propose: that a message headed for a distant station need only be forwarded in the correct general direction. For example, suppose that all states bordering Canada, Mexico and the Pacific Ocean spoke one language, that all other states spoke a different language and that the only bilingual stations were in Chicago. Then either a message from Denver to Los Angeles would get all the way to Las Vegas before getting rerouted to Chicago, or else stations in Denver would have to keep track of the regional languages and the locations of polyglot stations. Of course, the situation becomes worse if the mixture of relay stations changes rapidly with time and with only loose local coordination, as I think it is important to allow.

Since a CIE Net should be widely accessible to a major portion of the personal computer community, and since a universal language hardly precludes the use of more highly optimized languages, the most important property of a universal language is that it is most likely to be available to the highest portion of people in the community. (Don't forget that stations are free to agree on a more optimal language between themselves; a universal language only serves the purpose of assuring that they will be able to agree on some language at all.) Thus, even though I propose an asynchronous serial transmission mode at a certain speed because almost all current hobbyist equipment can handle it, there is no reason why stations could not (or should not) agree to transmit faster by a factor of three (or a hundred), or even use 16 parallel synchronous megabit lines, for example.

Before I give the details of the universal language, let me point out the light in which I present the details. All the details allude to standards that are widely accepted in the established computer community. Details are given here to identify the standards and to give you a quick summary of their contents. They are not given to specify a standard; for example, I will make no at-

tempt to give tolerances on critical timings.

Since far more interfaces, terminals and programs are compatible with the Model 33 Teletype than are both incompatible with it and also compatible with any other single convention, part of the universal language incorporates those conventions. That is, the universal language I propose includes sending ASCII at 10 cps asynchronously. Since these protocols only need the characters used in the radix-41 representation plus the six characters, comma, colon, space, slash, carriage return and line feed, there is no need to take a stand on any other part of ASCII, such as the varying representations of altmode or of the arrows. Since far more people have access to the regular private party telephone lines (usually dial-up) than to any other telecommunication media, those phone lines are also included in the universal language that participants can always use when no better means is mutually agreeable. Also, since most hobbyist modems use the Bell 103A conventions, they are a part of the universal language. That is, the station from which the phone call was originated transmits binary data as the audio frequencies 1070 Hz and 1270 Hz for zeroes and ones, respectively; and the station answering the phone call transmits on 2025 Hz and 2225 Hz, respectively. That, then, is the universal language.

There is no requirement that the hardware be implemented in hardware; the only requirements imposed here define the way the functional units behave. To fix ideas, though, we will define two functional units that serve as modems. A modem that transmits on the frequencies used by the originator of the phone call and receives on the other pair will be called an originate-mode modem; one that transmits on the pair used by the answering station and receives on the other will be called an answer-mode modem. Note that there is no requirement that any station be capable of automatically placing or answering a phone call, though either capability (especially the latter) may prove attractive and economically feasible to some stations. Also, note that some popular standards (such as Altair (S-100) bus or RS-232C) deal only with conventions internal to a station and so are entirely irrelevant to this set of protocols. Finally, since many extant computers that could be hosts to stations in a CIE Net take unyielding and conflicting stands on whether a line is to be full or half duplex and whether transmissions are to be handled a line or a character at a time, these protocols can handle all four cases rather than taking any stand on the issue.

The Radix-41 Representation

Certainly, the representation of binary data in a radix-41 coding is one of the more obscure features of my suggestions. There are several motivations, however. The most important motivation is to allow stations to transmit arbitrary binary data through relay stations and intermediate CIEs that may not be able to handle binary data, especially an intermediate CIE that is implemented in string BASIC on a host that does not give it access to machine language. Using radix-41, a station that cannot use binary can instead fall back to the more basic properties of arithmetic with small integers. The interstation protocol must also exhibit a high resistance to transmission errors, and it is easier to design a code based on a prime number (such as 41) than otherwise. Since phone line noise typically comes in bursts rather than being isolated, the code used here is optimized to detect bursts of errors (treating isolated errors as a special case), and it relies on retransmission to correct the errors.

I chose the particular prime number 41 for a couple of reasons. I contemplated the character sets representable in Baudot and available to a number of string BASICs and decided that their common ground included at least the capital letters, the digits and not too many other characters. For example, it seemed that a radix-47 representation would be unduly awkward for a number of implementations. The number 41 also has the interesting property that its cube is just over 65,536, so a 16 bit number can be represented by a 3 digit number in radix-41. Thus, radix-41 can represent binary data with a data rate of 5.33 bits per character, or 1.5 symbols per 8 bit character. (Elsewhere you will find a text compression scheme that compensates for this inefficiency by representing text as binary data, using an average of 5.24 bits per character.) The radix-41 representation is oriented to stations that can represent numbers up to 65,535, but it can also be handled pretty well by stations that can only gracefully handle numbers up to 1,681.

The table of radix-41 representations (figure 6) shows how to represent the digits of a radix-41 number as characters of ordinary text. The radix-41 representation of a 16 bit binary number can be found by dividing the 16 bit number by 41 and dividing the quotient by 41 again; the radix-41 digits are the two remainders and the second quotient. (Dividing by a constant can be considerably faster than general division, as shown by listing 1. Since the digits become known and are used in opposite orders, their order of transmission is arbitrary; one can appeal to the intuitive notion that they be transmitted in the order of their significance, though, and say that the second quotient be transmitted first, then the second remainder and finally the first remainder. In this connection, note that the table of radix-41 representations in figure 6 specifies characters, not their ASCII representations; it is understood that a Baudot (or other non-ASCII channel) will use its own representations of the characters.

Listing 1: A divide by 41 algorithm specified in symbolic notation for an 8080 processor. This algorithm is used in the radix-41 computations used to encode data for the CIE Net as shown in figure 6. This listing represents each instruction as an 8080 operation code followed by symbols for register operands, terminated by a semicolon. One line is devoted to each major step in the algorithm as highlighted in comments which begin with an asterisk (*).

```
DIV41: *DIVIDE BY 41  IN 8080 MACHINE CODE

*GETS:   DE = DIVIDEND
*GIVES:  ABC DESTROYED
*        DE = QUOTIENT
*        HL = REMAINDER

*TAKES 354 CYCLES = 177 US (NO WAIT STATES), OCCUPIES 59 BYTES

*ASSUMES DIVIDEND OBEYS 0 =< X = < 65535

*USES THE FACTS THAT 40 < 0.999*41 < 1024/25 < 41 AND THAT IF YOU FORM A
* TEST QUOTIENT Q2 = (25*X)/1024 (INSTEAD OF THE REAL QUOTIENT Q = X/41)
* AND A TEST PSEUDOREMAINDER RBAR = X – 41*Q2, THEN YOU HAVE
* –2*41 = –82 < –66 < –0.001*X < RBAR < 41, AND SO Q2–2 =< Q =< Q2
*ALSO USES THE FACT THAT 40*Q2 =< 65535 SO THAT YOU CAN AVOID OVERFLOW
* BY TAKING RBAR = (X – 40*Q2) – Q2

*NOTE: THIS PROGRAM WAS CODED FOR SPEED, NOT CLARITY, COMPACTNESS OR
* ADAPTABILITY
*ALSO NOTE: THIS PROGRAM WORKS ON AN INTEL 8080 AND IS SUSPECTED TO
* WORK ON A Z80 OR (WITH A MODIFICATION NOTED BELOW) ON AN NEC 8080
*ALSO NOTE: THIS HYPOTHETICAL ASSEMBLY LANGUAGE IS USED FOR COMPACTNESS
* OF THE LISTING

*SETUP
SUB A; MOV B,A;

*SET AHL = 3 * DE
MOV H,D; MOV L,E; DAD D; ADC B; DAD D; ADC B;

*SET AHL = (8 * AHL) + DE = 25 * DE
DAD H; ADC A; DAD H; ADC A; DAD H; ADC A; DAD D; ADC B;
*CARRY NOW CLEAR BECAUSE AHL = 25*X < 25*65536 < 8388608 = 2 ** 23

*SET BC = –(AHL / 1024) = –(AHL / 4) / 256
*         (= –(25 * X) / 1024 = –Q2)
RAR; MOV B,A; MOV A,H; RAR; MOV C,A;
SUB A; ADD B; RAR; CMA; MOV B,A; MOV A,C; RAR; CMA; MOV C,A; INX B;
*THAT SUB CLEARS THE CARRY BIT SO YOU DON'T SHIFT GARBAGE INTO THE TOP

*SET HL = DE – (40 * Q2) = (40 * –Q2) + DE
MOV H,B; MOV L,C; DAD H; DAD H; DAD B; DAD H; DAD H; DAD H; DAD D;

*SAVE Q2 IN DE
XRA A; SUB C; MOV E,A; MVI A; 0; SBB B; MOV D,A;

*SET HL = HL + BC = (X – 40*Q2) – Q2 = RBAR
* IF RBAR >= 0, THEN Q2 =< Q, AND SO Q2 = Q AND RBAR IS THE REMAINDER
DAD B; ORA H; RP;
*THAT ORA TESTS THE SIGN OF HL BECAUSE 0 =< Q2 =< 1680, AND SO A >= 0
****FOR AN NEC 8080 TOO, THE ORA SHOULD BE REPLACED BY SUB A; ADD H

*OTHERWISE Q2 > Q, SO SEE IF Q2–1 = Q
DCX D; LXI B; 29; 0; DAD B; RC;
*29 IS HEX FOR 41, AND THE 8080 STORES THE LOW BYTE IN THE LOW ADDRESS
*THE DAD SETS CARRY IFF IT MAKES HL GO POSITIVE

*FAILING ALL THAT, IT MUST BE THAT Q2–2 = Q
DCX D; DAD B; RET;
```

There is an issue of how to most economically use 16 bit words to represent data of smaller natural sizes, such as 8 bit bytes or the smaller fields of my compressed text. Clearly, they should be packed, several

Figure 6: Definition of a radix-41 character set for use in CIE Net protocols. This character set as expressed in ASCII is highly error tolerant, and is consistent with most more elaborate graphic coding schemes.

	0	8	16	24	32	40
0	(	7	F	N	V	)
1	0	8	G	O	W	
2	1	9	H	P	X	
3	2	A	I	Q	Y	
4	3	B	J	R	Z	
5	4	C	K	S	*	
6	5	D	L	T	+	
7	6	E	M	U	–	

to a word, but in which order? People do not universally agree, and convincing arguments can be advanced for both sides. All the arguments have their merits, but the one I found most persuasive is an appeal to intuition: we are used to writing the more significant digits of a number before the less significant digits, and people generally tend to be confused at the notion of reversing their order. Therefore, my schemes all assume that, when several fields are packed into a 16 bit word, the first fields will occupy the more significant positions.

The error resistance of radix-41 derives partly from the fact that, when the characters representing the radix-41 digits are transmitted in an 8 bit code, they only use 1/6 of the representable combinations. Were that fact not modified by another property of the ASCII representation of the radix-41 code, more than 83% of the random errors could be detected by rejecting any transmission not entirely composed of characters in the radix-41 set. Unfortunately, the radix-41 characters are clustered quite close to one another in ASCII (in terms of their hamming distances), so radix-41 is actually somewhat less resistant to errors than an optimally chosen ASCII set.

Text Compression

The whole point of this net is to transmit information, usually text, and one of its most limited resources is channel bandwidth. Now, text has a high degree of regularity, and we are used to capitalizing on the regularity by using such devices as alphabets and the ASCII character code. ASCII uses seven bits to represent each character, but it still leaves a large residue of regularity that can be used to further compress text. For example, if two people agree to confine their conversations to a particular list of 65,000 English words, they can represent each word as a 16 bit binary number, using an average of less than three bits to represent (the equivalent of) each character.

I propose a slightly different scheme for compressing text for transmission through a CIE Net. It is used at the option of the person sending a message, and so it represents little impediment to applications to which it is ill-adapted. It represents the entire ASCII character set, but the most frequently used characters have quite short representations. The representations vary in length from three bits (for E and T) to 15 bits (for NAK and DC2), with a calculated average of 5.24 bits. Note that, with more computation or intermediate storage, text can be compressed much further. For example, the dictionary of 65,000 English words just mentioned only uses 2.67 bits per character. The compression scheme I propose seems to be a reasonable compromise between the conceivable extremes.

The compression scheme is best described from the point of view of a program that decompresses the text. The details are in the tables of compressed representations in figure 7, but the general scheme is as follows. The receiver reads the first three bits and uses their values to retrieve the proper entry of a decoding table. The entry may indicate that the three bits represent a character, or they may direct the receiver to use the next few bits with one of three additional decoding tables. This process is slightly complicated by the fact that each of the four decoding tables is actually doubled, and the receiver must keep track of whether to use the upper case table or the lower case table. Initially, the receiver will use the upper case table, and the compressed codes allow for temporary or permanent case shift and for unconditional reset to a designated case.

For example, the word "fie" is represented (in context) by the 15 bit string 110,010,101,000000 (with byte boundaries emphasized by commas). Note that the coding scheme also allows the encoder to detect and further compress repetitions of a single character. Thus, a gap of five spaces can be represented by the 15 bit string 111,11110,0010,100.

You may have noticed that the compression tables give compressed notations for over half the ASCII codes, an escape to full ASCII, and no expression for any necessary control functions outside the normal ASCII repertoire. There's a purpose to that. The additional control functions can be provided by using a notion of hidden characters: each character that has a compressed notation can be thought of as hiding its ASCII representa-

tion, which is then available for other uses. I propose hiding four control functions under four letters of the upper case alphabet, as follows:

A – Change to lower case permanently;
B – Change to upper case permanently;
C – Change to another compression scheme (The next eight bits give the number of the new compression scheme.);
Z – (Reserved for future expansion of the repertoire of control functions).

Thus, a change to lower case permanently is represented by the 15 bit sequence 111,11111,1000001.

Encryption Considerations

A CIE Net would differ from most other information processing setups by trying to appear attractive to people for possibly

First Three Bits (xxx)		
First Three Bits xxx	Upper Case	Lower Case
000	E	e
001	T	t
010	O	o
011	A	a
100	<Space>	
101	See *	
110	See **	
111	See ***	

Next Three Bits * (101 xxx)			Next Three Bits ** (110 xxx)		
Next Three Bits xxx	Upper Case	Lower Case	Next Three Bits xxx	Upper Case	Lower Case
000	I	i	000	<crlf>	
001	N	n	001	C	c
010	S	s	010	F	f
011	H	h	011	P	p
100	R	r	100	M	m
101	D	d	101	Y	y
110	L	l	110	G	g
111	U	u	111	W	w

Next Five Bits ***

	(111 00 yyy)		(111 01 yyy)		(111 10 yyy)		(111 11 yyy)	
yyy	Upper Case	Lower Case	Upper Case	Lower Case	Upper Case	Lower Case	Upper Case	Lower Case
000	V	v	0		8		:	;
001	B	b	1		9		<	=
010	X	x	2		#	$	>	?
011	Q	q	3		!	&	<Comma>	
100	K	k	4		'	(	<xcase>	
101	J	j	5		)	*	<pcase >	
110	Z	z	6		+	–	<Repeat>	
111	<period>		7		"	/	<ASCII>	

Notes:

<crlf>: Carriage return followed by line feed.
<xcase>: Change to the other case for the next character only.
<pcase>: Change to the other case permanently.
<Repeat>: Take the next four bits as a repeat count; repeat the following character that many times and three times more.
<ASCII>: Take the next seven bits as an ASCII character code (also see text).

*Figure 7: Definition of a compressed data encoding scheme which is optimized for the frequencies of letters in typical English language texts. All codes are either upper or lower case, depending on the last case setting encountered. The first three bits of an atom of text contain a specification of a space, one of the four most common letters, or a reference to one of three possible extensions of the 3 bit word. For atoms with the first three bits containing 101 (marked by *) or 110 (marked by **), one of two alternate second level tables of eight possible characters is specified. For atoms which begin with 111 (marked by ***), the second part of the atom is a 5 bit field which has numbers, special characters and the lesser used alphabetic characters. The 5 bit extension form also has four special codes which provide for case change, permanent case change, character repeats, and escape into ASCII. If the ASCII escape is used, seven additional bits specify the ASCII code. Definition of an explicit upper or lower case setting can be done by implication (upper case is in effect at the start of a text string), or by an escape into ASCII followed by the ASCII code (see text) which forces an explicit case setting.*

sensitive information but still providing almost no restrictions on accessibility of the data containing that information. For example, an order for several hundred dollars worth of computer manuals might be placed in a CIE's outgoing message files, relayed through some unpredictable collection of relay stations and intermediate CIEs and finally placed in a supplier's incoming message files. If the source or destination CIE, for example, is so small that it uses volunteer relay stations and its host doesn't provide good file protection (eg: if all CIE subscribers look like one person to the host), then that message is accessible to many people.

Encryption provides a partial answer to the problem. The basic property of encryption is that it makes data unintelligible without making them inaccessible. That is, any encryption scheme worth its salt will prevent the "bad guys" from

forging or
perusing

your information. Without access restriction, however, an encryption scheme is powerless to prevent "bad guys" from

deleting,
garbaging or
recording

your data. In the context of a CIE Net, the first two kinds of interference can be detected by means of the reply mechanisms (if garbaging makes a message completely unintelligible) or by including redundancy information (eg: a checksum) with the information being encrypted.

Also note that encryption and compression interact in a peculiar way: an encryption algorithm endeavors to destroy the very regularity that allows a compression scheme to work. Since compression schemes are optimized to give the most compact representations to information having some appropriate kind of predictability, they must necessarily give less compact representations to less predictable information. If the encryption algorithm is very good, it will produce a result that is almost completely unpredictable; applying a compression scheme to that result will produce a representation that has *expanded* to an extent roughly commensurate with the degree it would normally have compressed it! In the context of a CIE Net, the wisdom to be drawn from that observation is that, when a message is encrypted and compressed, the compression should be done first.

Comparison with the PCNET

Given the preceding detailed exposition of the CIE Net design, it could be constructive to compare it with the PCNET design and highlight the differences and similarities. The PCNET has the same major goal as the CIE Net: to bring computer telecommunication to the individual. Since BASIC is the lingua franca of personal computers, the PCNET is also designed so that it can (largely) be programmed in BASIC. It also has a layered set of protocols, because that approach facilitates the formulation, comprehension, implementation and modification of the protocol set. Finally, since it is designed to be accessible to BASIC, it resembles the CIE Net in having a radix-41 representation of the interstation transmission blocks. (In fact, the checksum calculation described here is that of the PCNET because it is easier to implement than what I had originally specified.) More insight, however, can be gleaned from an examination of the differences between the two designs.

The PCNET isn't as strongly oriented to having a set of CIEs (or any other server nodes) as is the CIE Net. (This difference is one of emphasis, not one of substance: either design can easily be adapted to the opposite stance.) That is, the normal mode of operation in the PCNET will be for the person sending a message to place a direct phone call to the ultimate destination and send the message in a single hop. However, the PCNET is not committed to direct transmission: it permits the end-to-end message to arrive at its destination long after it was sent, and it tolerates long delays in the end-to-end acknowledgment. That is, the normal mode of operation in a PCNET is predicated on the ultimate destination (a personal computer) being receptive to a transmission at the moment the source spontaneously sends it. This solution is diametrically opposed to the notion of a CIE serving as a buffer: either the sender and receiver must schedule their activities appropriately, or the destination must be equipped for unattended operation, including answering the phone, running the proper programs and storing the message it receives. The price is hardware and software complexity at the destination node; the benefit is freedom from the CIE and its own attendant software complexity and need for explicit cost recovery procedures.

The PCNET may also capitalize on an optional capability for personal computers to automatically place phone calls, if some surprisingly thorny problems can be ironed

Acknowledgments

*This series of articles owes much of its strength to the thoughtful comments and perceptive criticisms of Dave Caulkins, Ron Crane, Peter Deutsch, Bernie Elspas, David Fylstra, Marc Kaufman, Bill Kautz, Robert Maas, Dennis McGhie and Jon Postel; it owes all of its weakness to me. . .***MW**

out. The worst problem is that errant (or malicious) hardware or software can intolerably inconvenience innocent bystanders. (Discussion on this point also unearthed the fact that even malfunctioning, or carelessly designed, hardware to automatically answer the telephone can be intolerably offensive.) Assuming those issues can be resolved, some PCNET nodes could increase their degree of automation at a cost in hardware and complexity of software.

The PCNET has an optional binary format for interstation transmission blocks in addition to the radix-41 format mentioned above. That allows it to utilize the phone line bandwidth more effectively than is possible in radix-41, but it can, of course, only be used between nodes capable of conversing in binary.

The PCNET has two layers of interstation protocol, where the CIE Net has only one. The second interstation level is used to multiplex several conversations in each direction between a pair of stations. Even at the present level of personal software sophistication, this facility can be used to transfer two files concurrently, say, with each file being transmitted during dead times in the other transmission. The CIE Net lacks this facility but would probably not be handicapped at first by the lack. The PCNET has no analog to the <protocol number>s of the CIE Net. I suspect that lack will cause a certain amount of awkwardness in a maturing PCNET.

The PCNET uses a worldwide addressing scheme (based on latitude and longitude) that makes the CIE Net's zip codes seem parochial by comparison. (About the only advantage of zip codes is that they are more compact, and thus marginally easier to remember. A CIE Net would probably very quickly adopt the PCNET scheme, replacing the optional USA prefix with a required "latlong" prefix.) The latitude and longitude have an important advantage over zip codes: a glance will tell you the general direction in which to forward the message. Thus, the PCNET trades a small amount of legibility for two important advantages.

The PCNET end-to-end message headers all look more like CIE Net <mail head>s than like CIE Net <message head>s. That is, the end-to-end message header is more compact on the CIE Net but more readable and more nearly self-describing on the PCNET.

In conclusion, then, these are the main differences between the CIE Net and the PCNET. In most cases, arguments can be advanced for each side, and it can be instructive to consider them and see what advantages each gains and what sacrifices it makes to gain them.■

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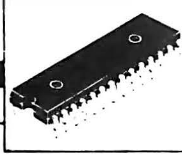


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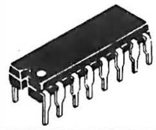
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4013	29	4053	89
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4024	67		



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7400	11	7482	50
7401	13	7483	62
7402	13	7485	75
7403	13	7486	26
7404	15	7489	1 75
7405	13	7490	40
7406	16	7491	51
7407	23	7492	40
7408	17	7493	40
7409	17	7494	60
7410	13	7495	60
7411	18	7496	60
7412	13	74100	28
7413	25	74107	28
7414	61	74109	22
7416	24	74121	29
7417	22	74122	38
7420	13	74123	48
7423	25	74132	65
7425	25	74141	70
7426	22	74145	65
7427	17	74150	88
7430	13	74151	61
7432	23	74153	61
7437	21	74154	95
7438	21	74157	55
7439	25	74161	55
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7441	70	74164	85
7442	37	74165	90
7443	59	74170	1 69
7444	59	74173	1 10
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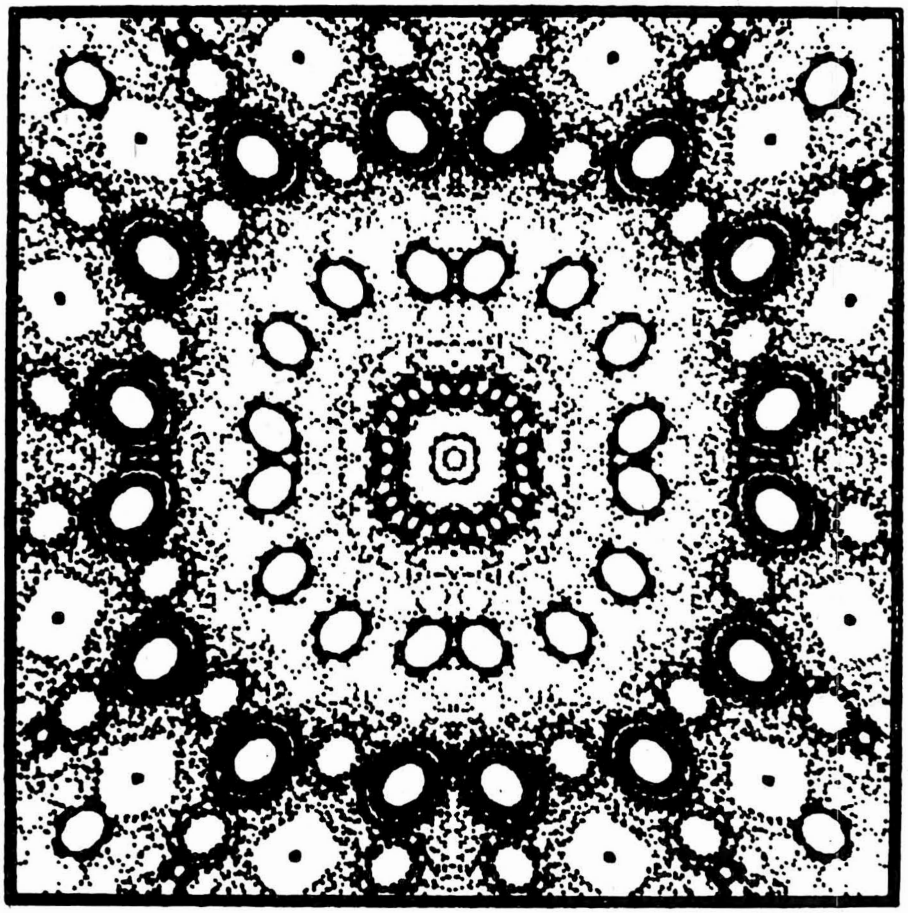
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Serendipitous Circles Explored

Figure 1: This picture was created using the algorithm described in "Serendipitous Circles" (August 1977 BYTE, page 70) by overlapping the results of using 24 unique starting points. Reflections are used to obtain a kaleidoscopic effect.

Eduardo Kellerman
IBM Corporation
System Products Division
Endicott NY 13760



In "Serendipitous Circles" by D J Anderson and W F Galway (August 1977 BYTE, page 70) a simple algorithm for generating computer art is described. The algorithm basically consists of computing a series of (X, Y) pairs and displaying them on a graphics device. Each (X, Y) pair is computed from the preceding one using two equations, one for X, and one for Y. All one needs to do is to supply an initial (X, Y) pair.

In this article are shown the results of experiments with different equations for generating the (X, Y) pairs. A storage scope was used as the graphics device, thus all points displayed are stored on the screen until a picture is "completed." Very interesting diagrams were obtained when the results of using several (X, Y) starting pairs were overlapped. Further enhancement was obtained by reflecting the patterns about the X and Y axes. All the pictures shown in this paper include these reflections. They were generated on a Tektronix 4015 storage display driven by an APL program.

Text continued on page 182

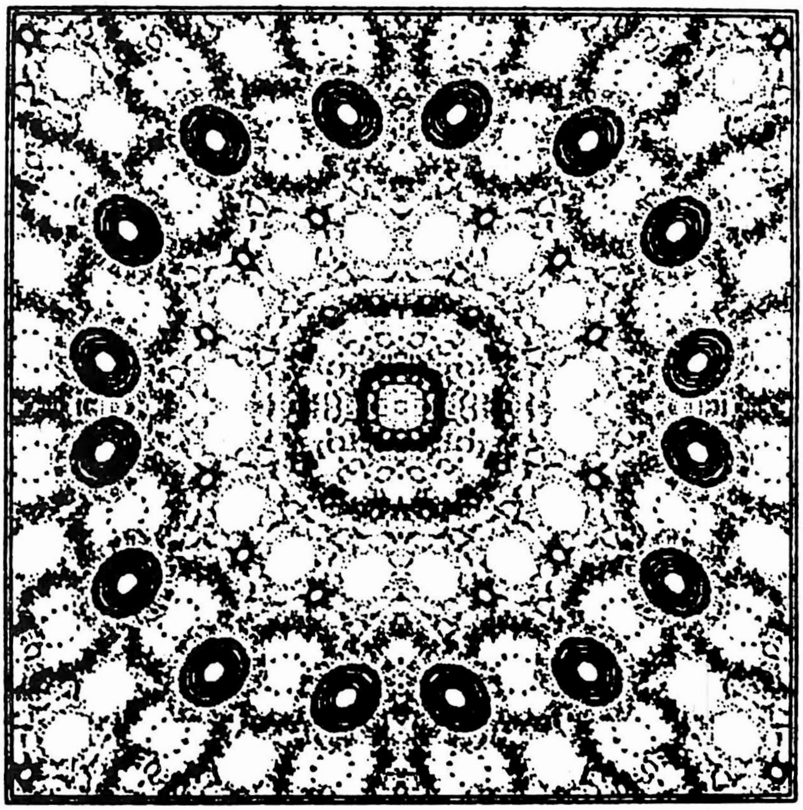


Figure 2: Here, the original equations were slightly modified to be:

X:=X−(Y/2)

Y:=Y+(X/2.1)

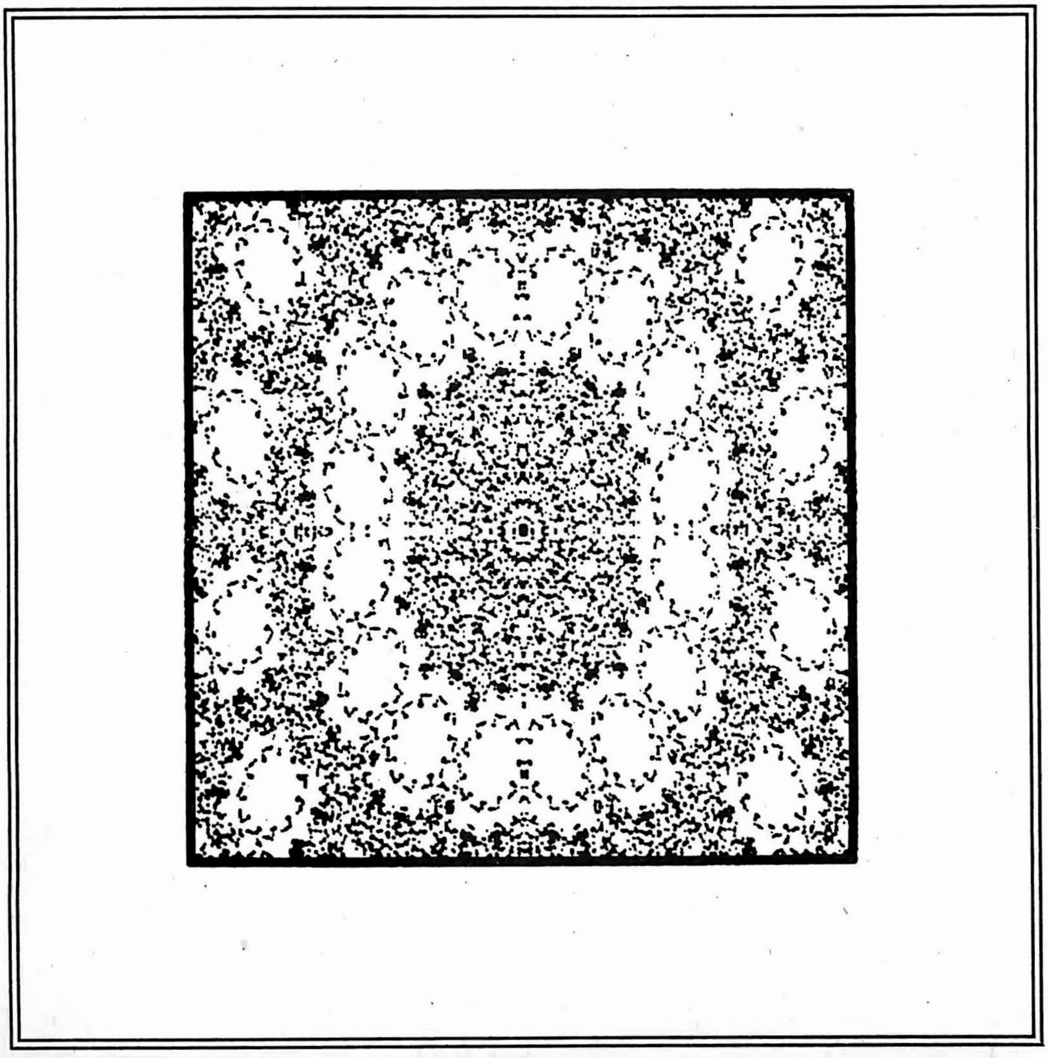


Figure 3: The equations used were:

X:=X−(Y/3)

Y:=Y+(X/1.5)

Figure 4: This Valentine's Day card was the result of using:
X:=X–(2 x Y)   Y:=Y+(X/1.1)

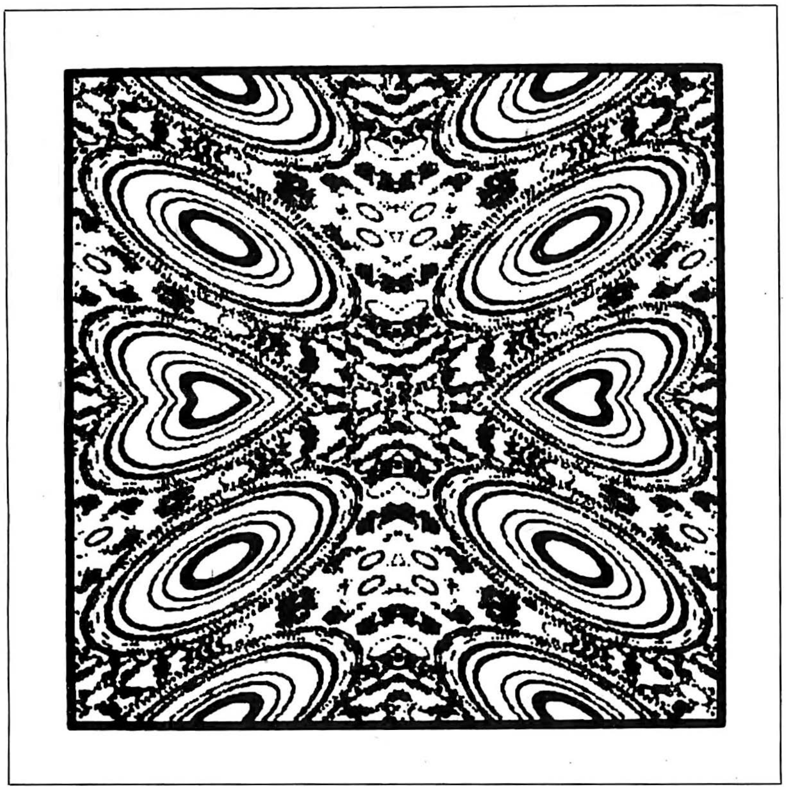
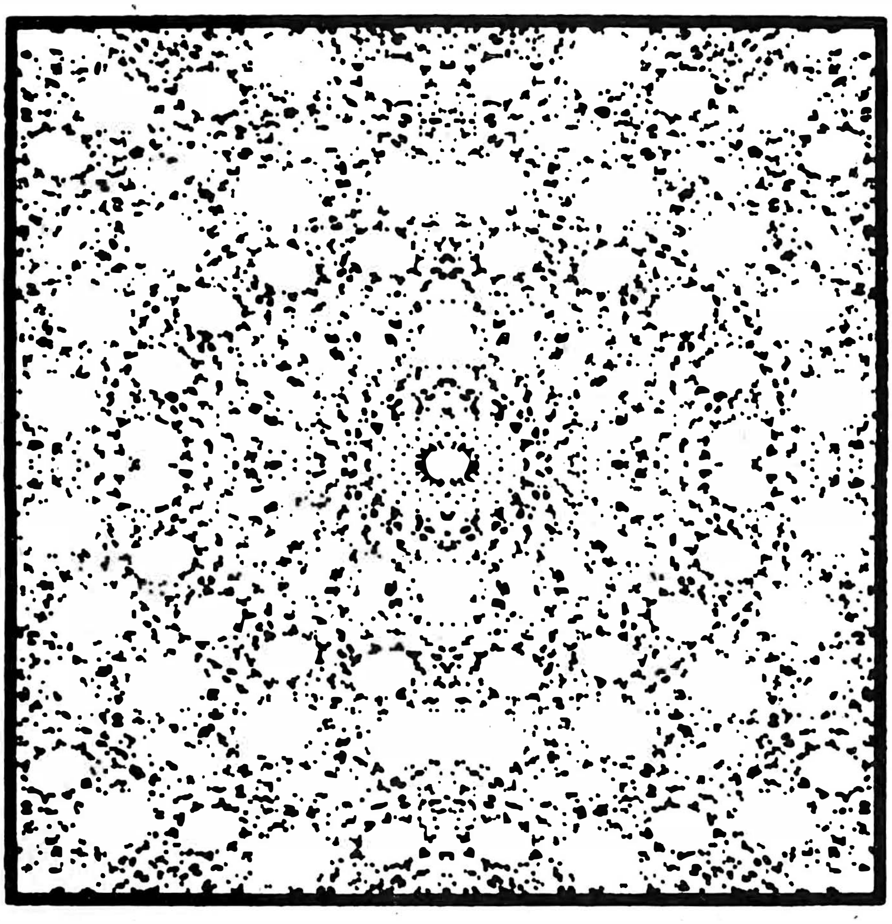


Figure 7:   X:=X–(Y/2)   Y:=Y+(X/4)



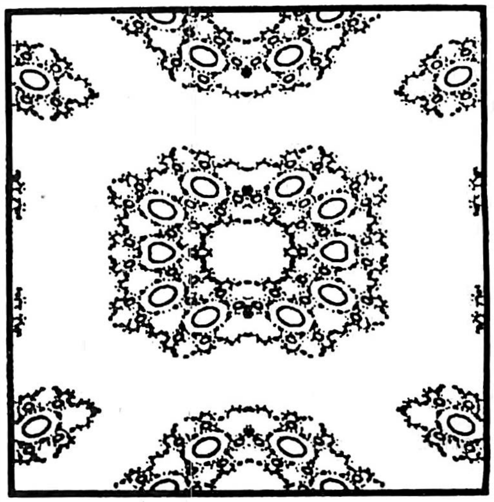


Figure 5:   X:=X–Y   Y:=Y+(X/2)

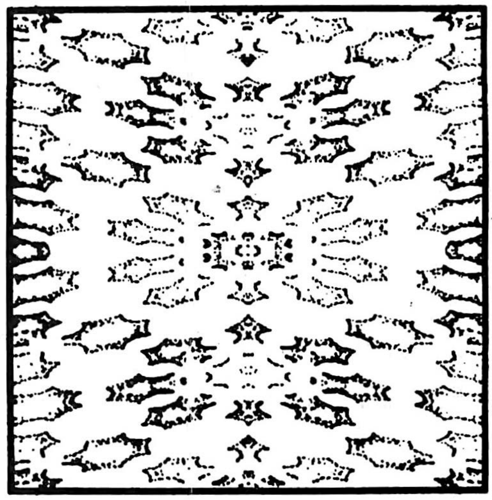


Figure 6:   X:=X–(2 x Y)   Y:=Y+(X/3)

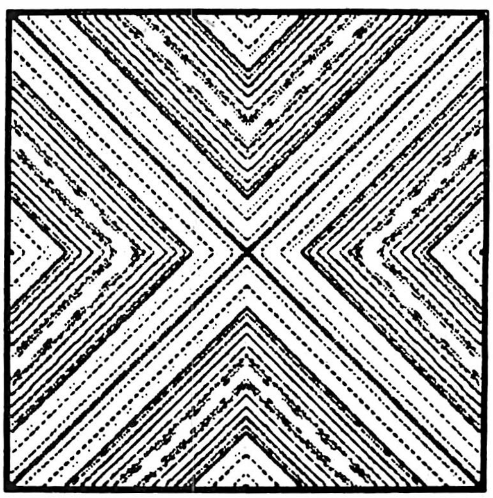
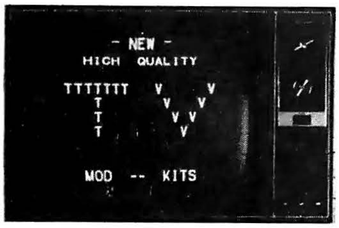


Figure 8: The circles become lines when:
X:=X–2 x Y   Y:=Y+2 x X

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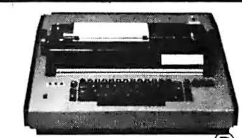
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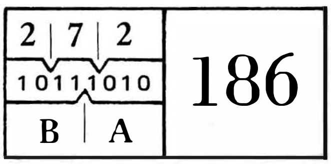
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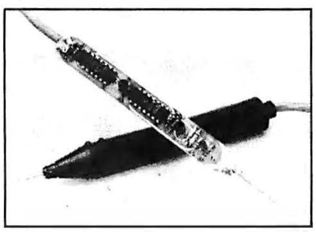
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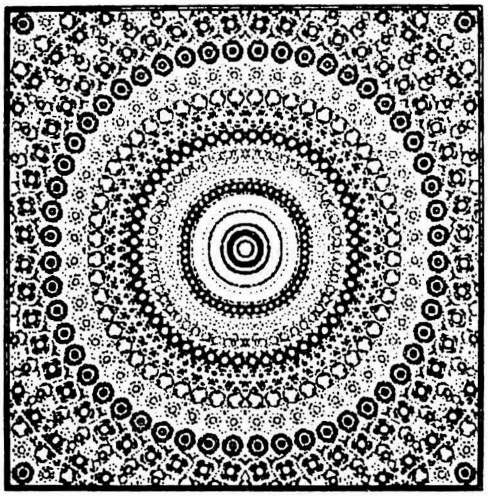
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Figure 9: Want lots of circles? Then use:

X:=X-(Y/8)

Y:=Y+(X/8)

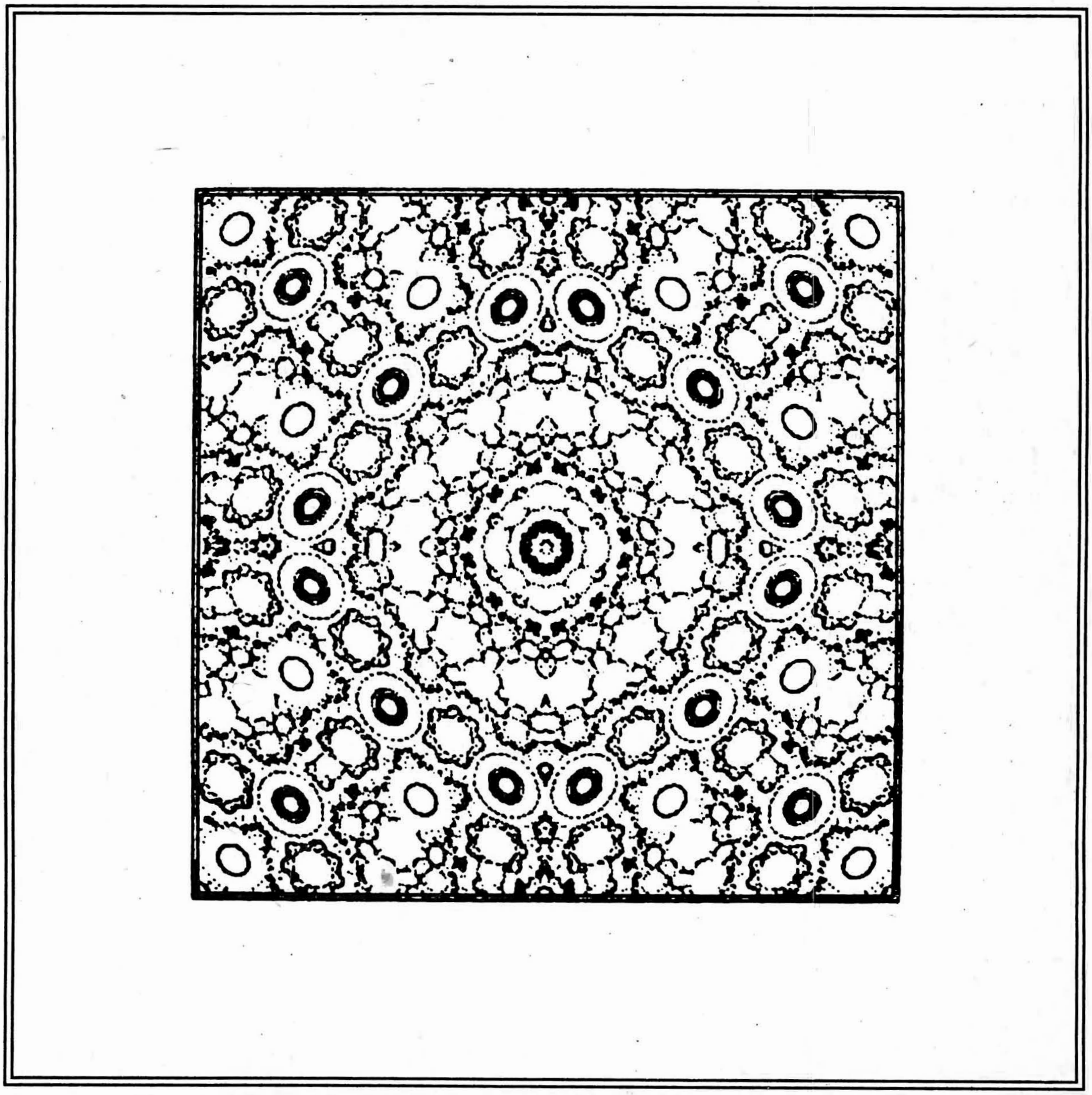


Text continued from page 179

In addition, all the pictures have the following in common:

1. A random number (4 to 32) of patterns resulting from different starting (X, Y) pairs were overlapped.
2. The starting X and Y values for each pattern were chosen randomly from the range 0 to 65536.
3. The number of points plotted from each initial (X, Y) pair was randomly chosen to be between 150 and 1050 points (before reflecting about the X and Y axes).■

Figure 10: X:=X+(Y/2) Y:=Y-(X/2)



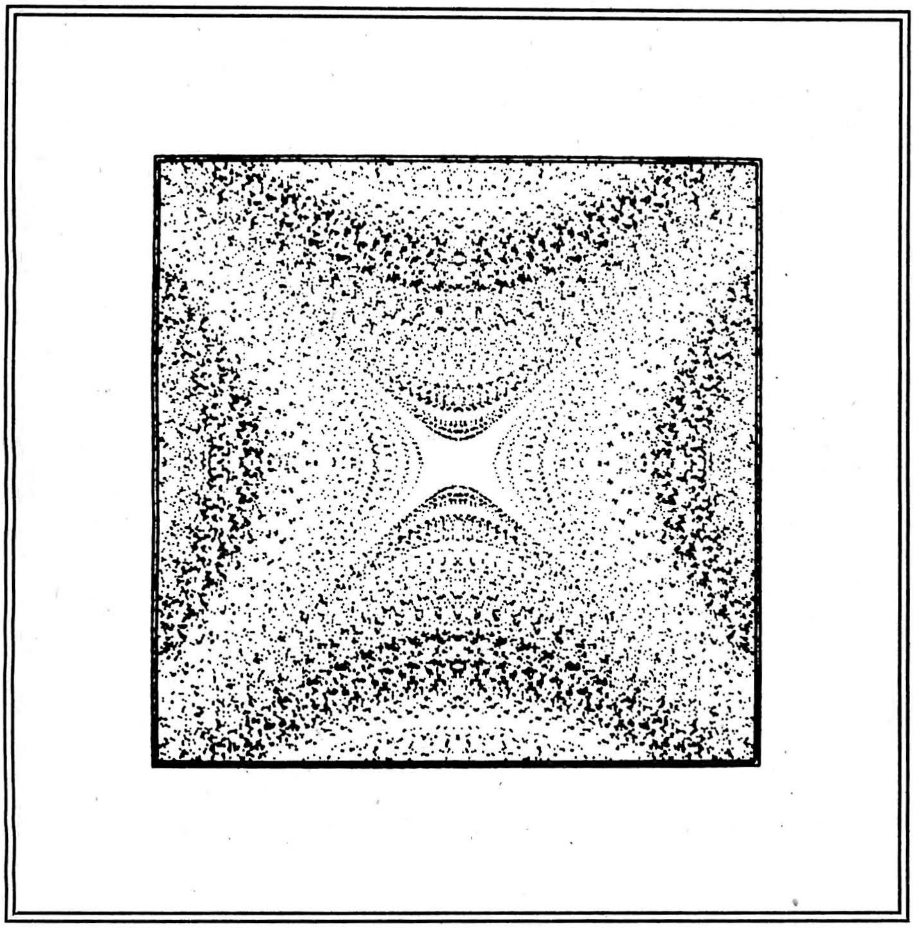


Figure 11: An unexpected result is obtained with:

X:=X−(Y/8)

Y:=Y−(X/8)

Figure 13: Here an "old" value of X was used when computing Y:

Xold:=X

X:=X−(Y/2)

Y:=Y+(Xold/2)

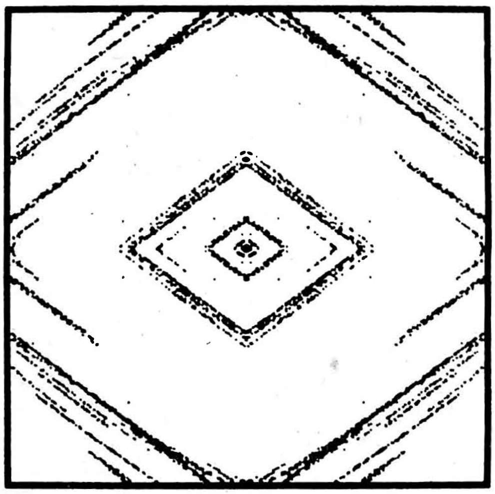
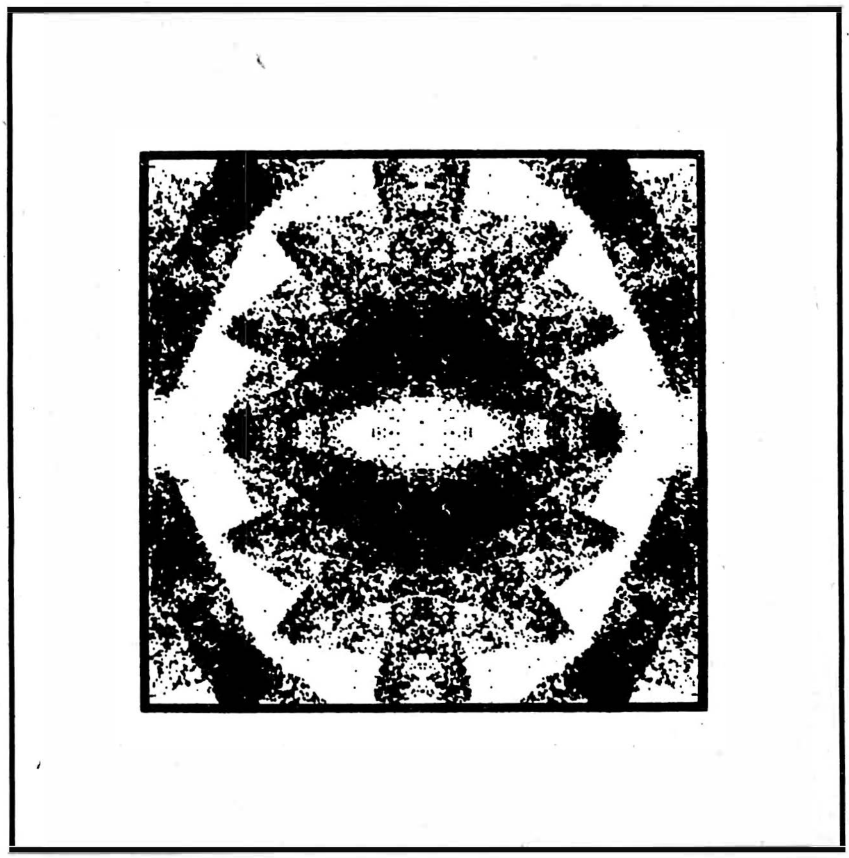


Figure 12: X:=X−(Y/1.1) Y:=Y−(X/2)



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- .KIT WITH 4K $99.95
- .KIT WITH 8K $149.95
- .Board alone $22.50

PROGRAMMING

- Burns up to 4-2716
- One shot for timing pulse
- Requires our digital I/O board for bus interface
- Plugs into our mother board
- Latched addresses no counters
- Can operate remote from mother board
- With 2 zero insertion force sockets

PRICE $49.94

KIM KIM

People keep asking if our boards are compatable with KIM. Our boards are compatable with most microprocessors and were especially designed for consultants, designers engineers, OEMs and others not wanting "hobby" type boards. Our boards are professional!
Now we even have an interface board that plugs into the KIM expansion connector. It maintains KIM's integrity while giving the user 13 other 4K memory blocks compatable with our mother board. All lines are fully buffered with powerful drivers. It has circuitry to write protect 4 separate 4K blocks of ram.
Inverting and non-inverting spare buffers are provided for customizing as required.
All memory slots are user relocatalbe.

HOW EASY CAN IT BE!!
PRICE $24.95
(and no need for S-100 "hobby"board)

Send check or money order to:

KATHRYN ATWOOD ENTERPRISES
P.O. Box 5203
Orange, California 92667
We accept Bank Americard, VISA and Mastercharge

California residents add 6% tax

For orders less than $25.00 add $1.25 for shipping

2102L1 RAMS

- High speed
- Low power
- 450ns

Sold in increments of 25 only
PRICE $1.20 ea.

WITH EPROM (8K) OR PROGRAMMING BOARDS, EXTRA ZERO INSERTION FORCE SOCKETS
$5.00 ea.

4K RAM BOARD

Assembled and Tested $89.95

In kit form $79.95

Our ram board is fully buffered. It is low power, static and 5 volt only. We use 450ns access rams on the board. The board size is 4½ x 6 inches.

BUY 4 OF OUR RAM BOARDS AND GET OUR MOTHER BOARD ASSEMBLY AT NO EXTRA CHARGE!!

ALL ATWOOD BOARDS HAVE:

- ..Plated thru holes. .
- ..5 Volts only. . . .
- ..Gold over nickle edge connector.
- ..Standard 44 pin connector. .
- ..6½x4½inch . . . .
- ..Professional not "hobby" . . .

Circle 7 on inquiry card.

CATCH-A-PULSE II®

LOGIC PROBE



- 10 Nsec pulse response
- Open circuit detection
- Replaceable tip & cord
- High input impedance
- Pulse stretching
- Multi-family

10 Nsec SPEED AT 3.5 to 15V LEVELS ONLY $39.95

Compatible with RTL, DTL, TTL, CMOS, MOS, and Microprocessors using a 3.5 to 15V power supply. Thresholds automatically programmed. Automatic resetting memory. No adjustment required. Visual indication of logic levels, using LEDs to show high, low, bad level or open circuit logic and pulses. Highly sophisticated, shirt-pocket portable (protective tip cap and removable coil cord). Eliminates need for heavy test equipment. A definite savings in time and money for engineer and technician.

Send $39.95 (Calif. residents add 6% sales tax) to: Pat Pend Dealer inquiries welcome

AVR ELECTRONICS

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Circle 9 on inquiry card.

SOFTWARE FOR CP/M

ANYONE RUNNING CP/M WITH BASIC-E OR C BASIC CANNOT AFFORD TO PASS UP THIS FANTASTIC OFFER. ONE LOW PRICE AND FAST DELIVERY FOR A STANDARD DISKETTE LOADED WITH APPLICATIONS PROGRAMS:

- MEDICAL/DENTAL BILLING PROGRAM
- LETTER WRITING PROGRAM
- VALUABLE UTILITIES PROGRAMS
- 15 ADVANCED GAMES
- PLUS MUCH MORE

PLEASE INDICATE BASIC-E OR C BASIC. SEND CHECK OR MONEY ORDER FOR $50.00 TO:

Computer Systems Associates
2415 Wilmington Avenue · New Castle, Pa. 16105

Also write for a quote for the lowest price on any IMSAI product.

PA residents add 6%

Circle 76 on inquiry card.

C A N A D A

PROMOTION ENDS MAY 30, 1978

8K (STATIC) $220.00 C.O.D.

INDUSTRIAL MICRO-ASSEMBLED AND TESTED
REGULARLY PRICED AT $250.00

COMPACCOUNT COMPUTER SALES
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WRITE FOR OUR FREE CATALOGUE

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Disc/3

DISC/3 COMPANY

COMPLETE MICRO BUSINESS SYSTEMS

SOROC IQ 120 Assembled	$ 899.95
LEAR SIEGLER ADM-3A kit	$ 799.95
IMSAI 8080 kit	$ 599.95
CENTRONICS Business Printer (132 columns)	$1145.00

Disc/3

DISC/3 COMPANY
1840 LINCOLN BLVD.
SANTA MONICA, CALIF. 90404
(213) 451-8911

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CALIFORNIA APPLIED TECHNOLOGY

32K-MEMORY CARD-$410
S-100 PSEUDO STATIC KIT

2708E-450-NANOSECOND-$14

2708 E PROM 650 NANOSECOND $10.95

80 MAJOR COMPUTER PRODUCT LINES AND AN EXHAUSTIVE LINE OF ELECTRONIC COMPONENTS

COMPUTERS
HARDWARE AND SOFTWARE
CUSTOM HARDWARE AND SOFTWARE RESEARCH AND DEVELOPMENT

P. O. Box 1239
TWENTY NINE PALMS, CA 92277
714-367-6996

FREE BASIC PROGRAM AND CATALOG

'ALEX IS COMING'

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SOLID CAREER OPENING WITH HEATH

You know us for our quality Heathkits – and for our reputation for "doing things right." Our progress story goes far back, and prospects are very favorable for the years ahead.

SOFTWARE DOCUMENTATION WRITER

An effective, proven technical writer needed to write Heathkit computer systems operations manuals and applications procedures. A B.Sc. CS or equivalent is required. Candidates must be familiar with LSI-11/PDP-11, software and applications programming, higher level languages, and operating systems, principles and techniques.

Salaries are competitive, with excellent benefits additional. Our ideal location is a pleasant, small community on Lake Michigan, 90 minutes from Chicago.

Please send resume in confidence, or phone collect to Ken Smith, (616) 982-3673.

HEATH COMPANY

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Software Professionals

Explore Opportunities For Rapid Advancement In New England - CONFIDENTIALLY!

Our clients are state-of-the-art companies looking for promotable creative software - engineers, and systems analysts/programmers.

Growth positions in the 15-40K range are available.

Applications are in diverse areas including *Graphic Arts, Text Handling Systems, Micro-Based Controllers, Manufacturing,* and *Inventory Control Systems.*

We would like to tell you more about these growth positions. All inquiries will be held in strict confidence.

Call us collect 603-888-5500 or send resume.

Touchstone Associates Inc.
Personnel Consultants
104 D.W. Highway, Nashua, N.H. 03060

Circle 141 on inquiry card.



SCOOP!! 4 MEGABYTE TAPE RECORDER!

QUAD 5 CHANNEL 1/4" TAPE TRANSPORT, ONE FURNISHED

$269.00 LOGIC FOR AUTO SELECT, REWIND, E OT, LOW LEVEL, & LAST CARTRIDGE—POWER REQ'D 12 V 5 AMPS DC-STD RACK PANEL 12 1/8" HIGH 19" WIDE 20" DEEP, WT 85LBS, FREIGHT COL. USED-GOOD COND-LIMITED QTY. DATA BOOK $10.00

.025 SQUARE PIN PUSH-ON TERMINALS,
FOR JUMPERS-PATCH-POWER-PLUG REPAIR, ETC., HARD TO FIND! 10/$0.50 100/$4.50

PC LEAD CAPACITORS 20/$1.00

70PF N1500 100VOLT 5% DISC
120PF 100VOLT 5% DISC
.01MFD 200VOLT TUBULAR CERAMIC
.005MFD 500VOLT DISC
.005MFD 100VOLT DISC
.0068MFD 100VOLT SQ. DIPPED POLY
— 6 PAX $5.00

.01MFD 50VOLT 5% POLY TUBULAR, LONG LEADS, 10/$1.00 100/$7.50

BI-PIN BASE T-1 3/4 12V 40MA
INCANDESENT 10/$1.00 100/$9.00

CORE MATRIX STRIPPED FROM COMPUTERS-8 PLANES-NO DRIVERS-NO DATA-
AS IS-NO RETURN. 256+BYTES $19.95, 1K BYTES $27.95, 4K+ BYTES $39.95. 2 ONLY 1620 ASS'Y GOOD COND EACH $125.00

CARD GUIDE & FRAME-15PR-5 1/2H 5 1/4W 12 1/2L; OR 15 SOCKETS ELCO NO. 7008-035-163-002 ON RAILS, YOU STRIP-CHOICE $9.95 EACH. OTHER SURPLUS-SEND $1.00 FOR LIST OR CALL 817-625-2961, MC, BAC, VIZA ACCEPTED. $10.00 MINIMUM ORDER

J&E ELECTRONICS SALES
P O BOX 4504, FT. WORTH, TEX, 76106

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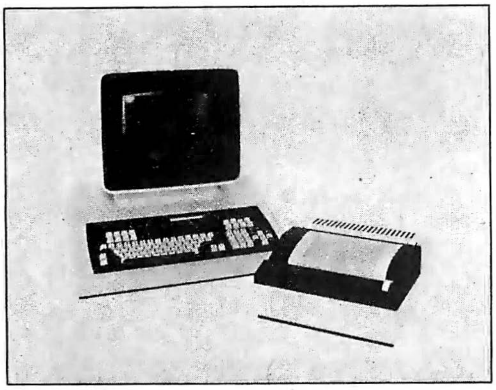
Electronics Engineer

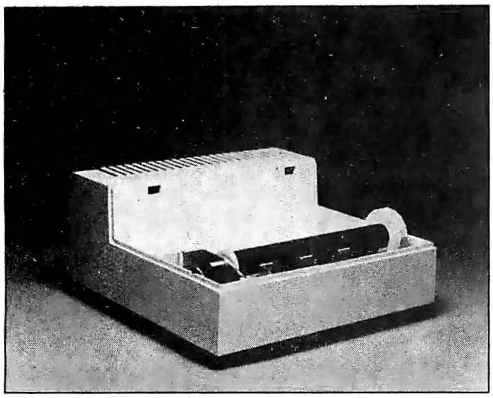
The Department of Chemistry of Hunter College seeks a person with a background in Electronics (B.S. in E.E. or equivalent) to maintain and repair a wide range of laboratory scientific instrumentation, including minicomputers, associated peripherals, and radiofrequency equipment. The successful applicant will also be able to design and build interfaces and other needed electronic equipment, and interact collaboratively with research personnel. Salary competitive. Interested applicants should send a curriculum vita and at least two letters of recommendation to Dr. Robert Lichter, Chairman, Chemistry Department, Hunter College, 695 Park Avenue, New York, N.Y. 10021. An equal opportunity employer.

Circle 146 on inquiry card.

What's New?

PERIPHERALS



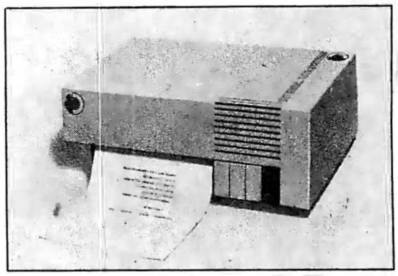


This Pussycat Is Fast and Inexpensive

The "Pussycat" Model 650 CRT Page Printer is capable of printing full 1920 character cathode ray tube screens in less than 20 seconds, with internal buffering so that CRT dialog is interrupted for only 2 seconds (at 9600 bps). The thermal printer accepts data at the maximum transmission rate over an RS232 serial line, and prints the screen image noiselessly at 100 characters per second sideways on a standard size sheet of paper, in a 24 line by 80 character format using a full 96 character ASCII set. The 9 by 12 dot matrix provides for descenders on lower case characters. The "Pussycat" uses thick film thermal dot arrays fixed in position for its printing heads, and has no moving parts other than its platen. Heating of the dots is controlled by an internal 6800 microprocessor. When printing blank lines the device's "slew rate" is five feet per second. The Model 650 measures 4 by 12 by 12 inches, weighs only 15 pounds, and is priced at $795 in OEM lots of 75. More information is available from Perkin-Elmer Terminals Division, Rte 10 and Emery Av, Randolph NJ 07801, (201) 366-5550.■

Circle 584 on inquiry card.

Inexpensive Impact Printer



The Integral Impact printer can print multiple copies on both fanfold and roll paper. It uses a 5 by 7 dot matrix to print the standard 64 character ASCII set at speeds up to 120 characters per second with up to 132 characters per line. Standard features include an RS232 and current loop serial interface at data rates from 110 to 1200 bps, and a parallel interface is also provided. Double width characters are provided, and switches select character sizes and line lengths from 80 to 132 characters per line. A reinking mechanism gives the ribbon an expected life of up to ten million characters. Housed in an attractive tabletop console with operator controls on the front panel, the Integral Impact is available at a unit price of $745 with discounts for larger quantities from Integral Data Systems Inc, 5 Bridge St, Watertown MA 02172, (617) 926-1011.■

Circle 585 on inquiry card.

Circle 42 on inquiry card.

Electrolabs 415-321-5601
POB 6721, Stanford, CA 94305

ESAT-100A: REVISED DESIGN ! *For Teletype, SC/MP, Jolt, Kim, SBC80, COSMAC.* **Electrolabs Stand Alone Terminal.** *Completely assembled, burned in and tested. Very reliable.* **$ 299.00**

NOW 80 char. X 24 lines 5x7 dot matrix ASCII, communicating with a serial, asynchronous 11 unit code, TTL compatible, 300 to 9600 Baud. Keyboard controls are: BACK SPACE, FORWARD SPACE, LINE FEED, CLEAR PAGE, CLEAR LINE, FULL/HALF DUPLEX, LOCAL/REMCTE, CURSOR ON/OFF, ODD/EVEN/NO PARITY. Output is comp video, 75 Ohms. Keyboard required is parallel out 7 unit ASCII with negative true strobes. Keyboard may tap up to 200 MA from the onboard 5V supply. Power required: 110 VAC @ 7 watts. You don't even need a computer, S-100 or otherwise. Mav be used with Modem for time-share terminal applications.



MODEM: Bell 103 Std. Vadic Card with originate & answer $75.00
DAA KIT (for above) 9.95

L.C. Option $39.00

EPROMS		
2716		$39.00
2708	450ns	11.95
2708	650ns	8.95
5204AQ		7.95
5203AQ		3.95
1702A		3.95
RAMS		
21L02	250ns	$ 1.59
21L02-3	450ns	1.19
F2101L1PC	450ns	1.68
2111AL-4	450ns	1.99
2114-3	300ns	10.95
2606-1	500ns	1.75
C3107-B	60ns	1.49
PD411D	135ns	3.99
PROMS		
82S2708	50ns	$22.95

MEMORY BOARDS

MEM-100-8KB $139
8K static for S100 bus, assembled, burned in and fully tested.

MEM-11-24KB $679
for PDP11-03 or Heathkit LS1-11. 24 KBy of RAM and 2KBy of 2708 ROM. Beautifully done board. Qualified through tests your CPU would flunk. Refresh CPU controlled. Includes 2708's.

OTHER NOTABLE ITEMS

Z80+XTAL	$27.95
Z80A+XTAL	33.95
8080A	10.95
2513 Char Gen	5.95
AY5-1013	4.95
MM5320	4.95

N3002 Bit Slice CPU $3.95
LS7031 8 decade CTR+ display driver up to 500 MHz w/external BCD CTRs $15.95

Verbatim
Removable Magnetic Storage Media manufactured by Information Terminals Corp.

MiniDiskettes	1-9	10-25	26-100
	$4.79	$4.65	$4.45

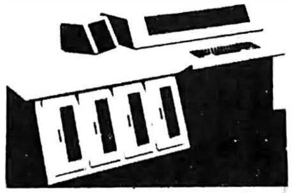
MD525-01 (Soft Sector) for: Intelligent Systems, Magnavox, Micr okit and Vector Graphics
MD525-10 (10 Sector) for: Digi-log, North Star, Polymorphic, Tei Inc., Wang
MD525-16 (16 Sector) for: Altair, Comtek, Micropolis, R2E, Realistic Controls and Teleray Research Inc.

Standard Size Diskettes	1-9	10-25	26-100
FD34-1000 (Soft Sector, IBM Std.	$5.99	$5.33	$4.79
FD32-1000 (Hard Sector, Inner dia.)			
FD65-1000 (Hard Sector, Outer dia.)			
Cassettes	1-9	10-25	26-100
R-300 Digital Direct	$5.25	$4.99	$4.35

I-150 For digital recording on audio recorders 2 for 8.95

RECERTIFIED DISKETTES fully guaranteed 3740 type 10/27.95

SYSTEM BUY OF THE YEAR ! **TEALTRONIC 2500**



includes 165cps bidirectional matrix printer, ASCII keyboard, wide band video monitor, FOUR Shugart 800 floppy drives, high speed CPU structured from 2900 bit slice chips to execute in IBM's ACL business language and containing 32K of memory. Regulated, protected cool running supplies for all of these items.

NOTE: In Europe these fetch $19,000. One of these with a LSI-11 would be incomparable !

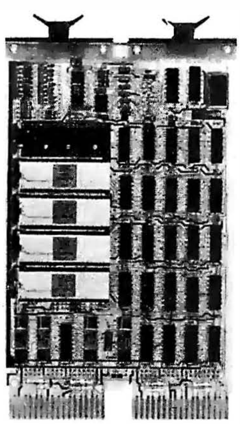
All New In Console including software	$5775
With 2 Drives	$3900

100% GUARANTEE ! We offer a money-back guarantee on the products that we sell. Full refund or replacement for any unsatisfactory products returned within 15 days of purchase. Our magnetic media is certified 100% error-free, shipped fresh from refrigerated storage. FREE CATALOG ! Free catalog of IC's, components, word processing supplies, useful devices and equipment will be sent in response to each inquiry and order. Call for information on quantity prices and special discounts.

ORDERS NOW BEING TAKEN FOR: **THE NOT-SO-DUMB TERMINAL** *80 char.X50 In. rolling full ASCII stand alone communicating Z-80 based terminal. Smarter than the "Owl," includes EBCD to ASCII translator. Options for 256X256 graphics. 100 lines, full editing, etc. Requires KDB and a reasonable monitor such as a slightly modified TV.* **$489.00**

LSI-11* COMPONENTS

Manufactured and tested by Digital Equipment Corporation. Compatible with DEC PDP-11/03 and Heathkit H-11. Or build your own computer using the housing assembly. All cards 8.5 in. x 5 in.



KD11-HA LSI-11/2 Central Processor Unit Includes power Includes power fail/auto restart, I/O DMA port, real time clock input and vector interrupt handling ....$ 695

MSV11-DA 4kx16-bit RAM, on-board refresh ....$ 350

MSV11-DB 8kx16-bit RAM, on-board refresh ....$ 675

MSV11-DC 16kx16-bit RAM, on-board refresh $1095

H9281-BB 8-card housing assembly and backplane ....$ 155

Other components available, write for catalog. We reserve the right to limit quantities.

MICROPROGRAMMING INC.
12033 Riverwood Drive
Burnsville, MN 55337
Phone: (612) 894-3510

Terms: Prepaid or COD (10% Deposit). Package Discount—Buy a CPU and memory, deduct 5% of entire order.

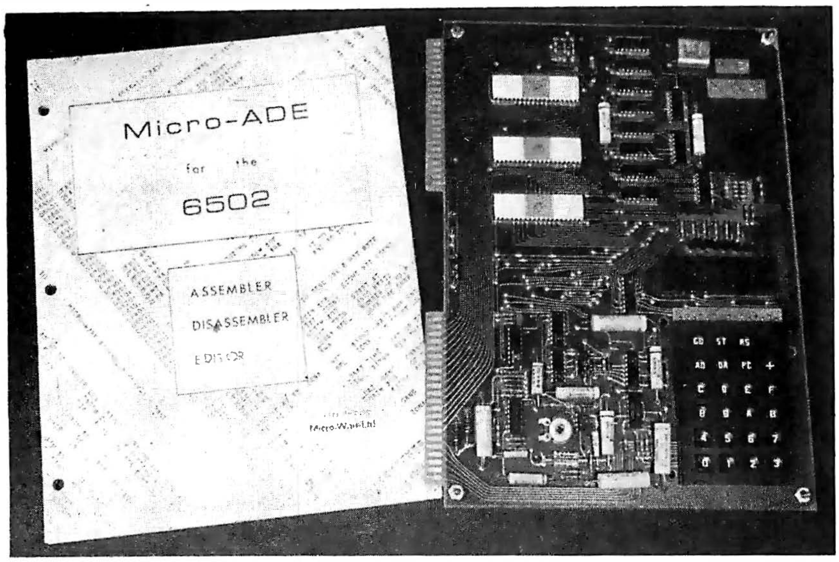
*LSI-11 is a trademark of Digital Equipment Corporation

Circle 68 on inquiry card.

What's New?

SOFTWARE

6502 Assembly Language Programmers Take Note



Micro-ADE is a complete assembler, disassembler and text editor package for 6502 based computers, customized especially for the KIM-1 with at least a 4 K memory expansion board. The two pass assembler can be used to assemble small programs directly in memory, or it can read source code from one cassette recorder and write object code on another for large programs. Program and symbol table listings may also be produced. The disassembler translates object code back into assembler source code, optionally using the assembler's symbol table to produce a fully symbolic listing. The text editor includes automatic line numbering, a FIX command to edit parts of lines, and the ability to save, load, and copy programs or data from one cassette to another.

The entire package, including a set of high speed tape cassette input output routines for the KIM-1, fits in 4 K bytes, optionally in read only memory. Documentation of the symbol table allocation and source text format makes it possible to use the assembler, disassembler and text editor with other system software packages, and the entire set of input and output routines for the cassettes and terminal are provided in commented source code form with a narrative description to facilitate interfacing the package to other IO devices and operating systems. The comprehensive 56 page user manual covers every aspect of using the package, even to the point of adding motor control relays to the cassette recorders.

The Micro-ADE package including the user manual, hexadecimal program listing, and paper tape or KIM-1 cassette costs $25, while the complete commented source listing of the entire package is available for an additional $25, from Micro-Ware Ltd, 27 Firstbrooke Rd, Toronto Ontario CANADA M4E 2L2.■

Circle 628 on inquiry card.

Circle 92 on inquiry card.

California Industrial

Post Office Box 3097 B • Torrance, California 90503

Point Of Sale COMPUTER

$179.50 set



Manufactured by TRW Data Systems for the fast food industry. Designed for error-free data entry. The operator simply blackens the appropriate box on a mark sense card and inserts it into the form reader. The CPU searches internal programable drum memory for unit price and extends it by quantity, displaying the customer's grand total on the LED module.
Memory system is capable of retaining over 40 register items. Accumulated data may be pulled by a master computer.
This point of sale computer makes a super mark sense data terminal. The TRW 1336 is shipped complete with cables and self-contained +5 & ±12v. power supply.
Brand new in factory cartons. Original cost $7,000. Weight 100 lbs., shipped freight collect. **Operating instructions included.**

ELECTRONIC ENTERTAINMENT CENTER

Tennis-Handball
Hockey-Smash



Action-packed color entertainment for the whole family. Adjustable skill level controls allow players of all ages to compete in tennis, hockey and handball. This four game entertainment center turns your television into a video playground.

On screen scoring, live action sound and true component color makes this video center an excellent buy at only $24.88. Complete with antenna box and AC adapter.

Color $24.88

TELETYPE® MODEL 43



New from Teletype, the Model 43 is capable of printing 132 ASCII characters per line. Send and receive data at 10 or 30 char. per second. Keyboard generates all 128 ASCII code combinations. RS-232 interface, same as the popular Model 33. Data sheet sent upon request. Manufacturer suggested price $1377.00.

IMMEDIATE DELIVERY $1219

TTL model with NOVATION brand Acoustic Modem. $1419

HEXADECIMAL KEYBOARD

$34.95

Maxi-Switch hexadecimal keyboards are designed for microcomputer systems that require 4-bit output in standard hex code.
Each assembly consists of 16 hermetically sealed reedswitches and TTL "one shot" debounce circuitry.
Reliable low friction acetal resin plungers are credited for the smooth operation and long life of this premium keyboard.
Requires single +5 volt supply.



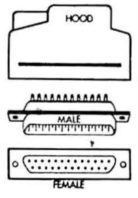
REGULATED POWER SUPPLY

Delivers 5 volts at 8 Amperes along with three other regulated outputs.
This used supply is sold "as is," but we still feel that this is the best buy you'll ever see in a regulated power supply. 75lbs., Schematics included.



Used $49.50
Shipped Freight Collect

CONNECTORS

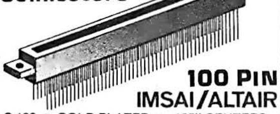


RS-232

DB25P male plug & hood **$3.95**

DB25S female **$3.95**

Edge Connectors



100 PIN IMSAI/ALTAIR

S-100 • GOLD PLATED • .125" CENTERS
Altair .140 row, soldertail..... $5.98 3/$16.50
Imsai .250 row, soldertail..... $4.98 3/$13.00
3 Level Wire Wrap .250 row... $4.98 3/$13.00

SPECIALS
W/W same as above without ears $3.50 3/$10
72 (dual 36) W/W .156" centers... $2.50 3/$6



$24.88

SPERRY UNIVAC KEYBOARD

The famous Sperry Univac 1710 Hollerith keyboard assembly is now available from California Industrial for only $24.88. The ideal computer input device for accountants and mathematicians. The numeric keys are placed on the lower three rows to resemble a ten key adding machine. This format allows one handed numeric data entry.
Original cost was $385. Used but guaranteed in excellent condition. Complete with documentation.

Quiet Buss™ S-100 MOTHER

The Quiet Buss from California Industrial is quality engineered. No short cuts have been taken to produce this mother board. Active termination circuitry prevents noise and crosstalk. Manufactured from extra heavy FR-4 epoxy glass. Features 2 ounce double thickness copper traces.

18 SLOT $29.95

FREE

MANUAL GRAPHITE DISPLAY GENERATOR

Modern technology has pioneered the development of this unique character printer. Our Manual Graphite Display Generator has the capability of producing the full upper and lower case ASCII set. Self-contained cursor assembly allows the operator to eliminate erroneously entered information.
Each unit is manufactured to strict tolerances as prescribed by standards set forth by California Industrial. One free with every order.

Scotch® BRAND DISKETTES

$4.98
10 for $45.



Please specify IBM 3740 series or 32 sector.
also MINI DISKS

Certified Digital CASSETTES

Won't drop a BIT!

$5.50



CALIFORNIA INDUSTRIAL is an Authorized Dealer of Scotch Brand Data Products

JOYSTICK $4.50



3 for $10.00

This joystick feature four 100K potentiometers, that vary resistance proportional to the angle of the stick. Perfect for television games, quad stereo and radio controlled aircraft.

450ns 2708 $9.95

8K UV Erasable MEMORY

5&12 VoLt REGULATORS

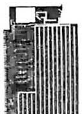
$1.19 ea.

	10	100
$1.19 ea.	.97	.88

	Negative	Positive
TO-3	LM320K()	LM340K()
TO-220	LM320T()	LM340T()

S-100 PROTOTYPE BOARD

$19.98



GP100-Maximum design versatility along with standard address decoding and buffering for S100 systems. Room for 32 uncommitted 16 pin IC's. 5 bus buffer & decoding chips. 1 DIP address select switch, a 5 volt regulator and more.
WW100-Wire wrap breadboard, similar to the GP100. Allows wire wrap of all sizes of sockets in any combination. An extra regulator position for multiple voltage applications.

21L02

LOW POWER 450 NS

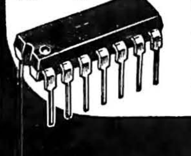
$1.19

SUPER BUY!

Lowest Price Anywhere

Our low power static RAMs are factory prime. Purchased, on contract, directly from one of California's leading semiconductor manufacturers.
Access time guaranteed faster than 450nS. Minimum purchase 32 pieces.
Sorry, credit cards can not be accepted on 21L02's.

7400	.13	7442	.59
7401	.19	7443	.79
7402	.19	7445	.89
7403	.19	7446	.99
7403	.19	7447	.99
7404	.19	7448	.99
7405	.19	7450	.25
7406	.19	7451	.25
7407	.25	7453	.25
7408	.25	7454	.25
7409	.25	7460	.25
7410	.19	7470	.25
7411	.25	7472	.39
7412	.35	7473	.39
7413	.49	7474	.35
7414	.79	7475	.49
7416	.39	7476	.39
7417	.39	7479	3.99
7420	.19	7480	.79
7422	.49	7482	.99
7423	.39	7483	.99
7425	.39	7485	.99
7426	.39	7486	.49
7427	.39	7488	3.40
7428	.49	7489	2.79
7429	.39	7490	.49
7430	.25	7491	.99
7433	.39	7492	.49
7437	.39	7493	.49
7438	.39	7494	.79
7439	.39	7495	.79
7440	.39		



7496	.79
7497	3.99
74100	1.19
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74120	1.79
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74154	.99
74155	.99
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4009	.69	4043	1.49
4010	.69	4044	1.49
4011	.25	4046	2.49
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4013	.49	4049	.79
4014	1.49	4050	.79
4015	1.39	4051	1.99
4016	.69		
4017	1.29		
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4019	1.79		
4020	1.39		
4021	1.49		
4022	1.25		
4023	.25		
4024	1.19		
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6800	24.95
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5314	2.95
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LM741 $.09

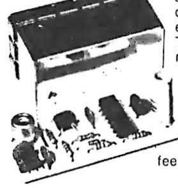
301H	.39	350N	.99
301CN	.39	351CN	.65
302H	1.29	370H	1.29
304H	1.29	370N	1.29
305H	.99	373N	3.19
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308H	.99	381N	1.79
308CN	.99	382N	1.79
309H	1.09	NE555v	.49
309K	.99	NE556	1.29
310H	1.19	NE565H	1.49
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311H	.99	NE566N	1.25
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312H	1.99	709H	.39
318H	1.79	709N	.39
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320K-12	1.19	723H	.55
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320T-12	1.19	725H	3.49
340K-5	1.19	733H	1.49
340K-12	1.19	733N	.99
340T-5	1.19	739N	1.19
340T-12	1.19	741N	.09
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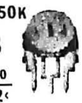
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Ten position **BCD**

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10	50
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MINIATURE SWITCHES



your choice

	10	50	100	1k
$.98	$.88	.81	.73	.66

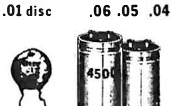
SPDT Miniature Toggles

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7107 jbt ON-OFF(mnt.ON)
7108 CK ON-(moment. ON)
Rocker JBT ____ DPDT
Rotary 3P-4-Pos.
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.01 disc	.06	.05	.04



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$1.75 ea.	$1.63	1.52	1.29

specify 7 or 8 pos.

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Coil 12 Volt dc.
7 Amp Contacts
P. C. Board Mount

Transistors

	ea.	10	50	100
2N2222A	.20	.18	.16	.15
2N3055	.69	.65	.59	.55
MJ3055	.79	.75	.69	.65
2N3772	1.59	1.49	1.39	1.29
2N3904	.15	.11	.09	.07
2N3906	.15	.11	.09	.07

Diodes

		10	25	100
1N4002	100v.	.08	06	.05
1N4005	600v.	.10	.08	.07
1N4148	signal	.07	.05	.04

jumbo red LED's	ea.	10	25	100
	$.15	.13	.11	.09



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Output: 12v.ct. 175mA. TRANSFORMER

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Circle 16 on inquiry card.

What's New?

SOFTWARE



A "Universal" BASIC Compiler

Futuredata Computer Corporation has announced a Universal BASIC Compiler, which can be used to generate code for the 8080, 8085, 6800 and Z-80 processors.

The product includes a high level debugger that allows program debugging without dealing directly with assembly language.

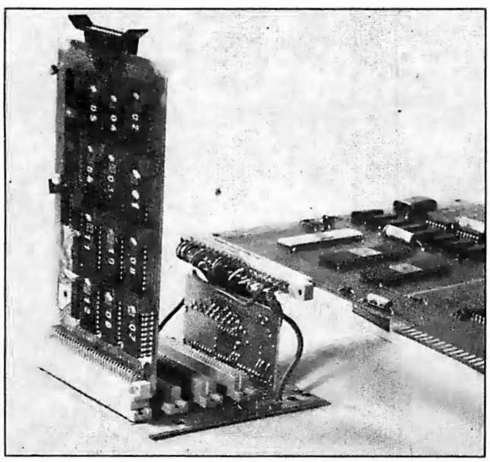
Programs written in BASIC can be compiled for any of the processors. The compiler eliminates the need to rewrite programs when switching from one processor to another. All standard BASIC statements are included plus string variables, array variables, bit functions, PEEK, POKE, INP and OUT functions. The user can intermix assembly language instructions directly in the BASIC program. The debugger allows the user to set and clear breakpoints with BASIC statement numbers and to display variables in memory using the BASIC variable name.

Futuredata BASIC has the option of outputting an assembly language source code of the compiled program to an editor file. Each BASIC statement becomes a comment in the assembly listing. The compiled assembly instructions follow the BASIC statement. This allows the user to optimize sections of the program by directly editing the assembly language after compilation.

The compilers run in systems with at least 32 K bytes of programmable memory and are available for any of Futuredata's disk-based Microsystems: the Microsystem/20 with dual 5 inch minifloppy disks, the Microsystem/30 with dual 8 inch floppy disks, or the Microsystem/32 with dual 8 inch double sided, double density floppy disk. Each Microsystem comes complete with an 8080, 8085, 6800 or Z-80 processor, a 960 character video display, a 53 key ASCII keyboard, memory peripherals, software and manuals.

The price of the Universal BASIC Compilers is $300 each. Contact Futuredata Computer Corporation, 11205 S La Cienega Blvd, Los Angeles CA 90045, (213) 641-7700.■

Circle 654 on inquiry card.



KIM-1 Software in ROM from Vienna

This KIM-1 accessory of European origin features a resident assembler and text editor in read only memory. The assembler is single pass and has 22 different error messages, and fits in 4 K bytes; the line oriented editor permits user defined commands and occupies 2 K bytes of read only memory (ROM). For input and output the KIM-1 cassette or Teletype interface is used. The programs in ROM are delivered on a European card which plugs into a KIM-1 expansion bus with room for four cards. The unit is available from Ernst Steiner, Geylinggasse 16, 1130 Vienna AUSTRIA.■

Circle 653 on inquiry card.

Text Editor Offers Conditionals and Macros

The Z-TEL text editor has, in addition to the usual text editing features, the ability to move blocks of text around in an edit buffer and the ability to define macros, test conditions and transfer control from one part of a command string to another, with nested iteration and backward search capabilities for added convenience. The editor is a relocatable, reentrant program running in 7 K bytes of memory and is priced at $50 on paper tape from Technical Design Labs, Research Park Bldg H, 1101 State Rd, Princeton NJ 08540, (609) 921-0321.■

Circle 652 on inquiry card.

New!

16K E-PROM CARD

Uses 2708's!

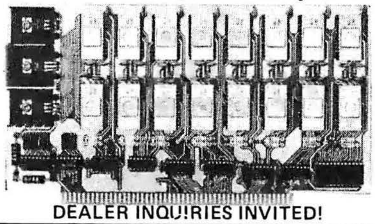
IMAGINE HAVING 16K OF SOFTWARE ON LINE AT ALL TIME!

S-100 (Imsai/Altair) Buss Compatible!

KIT FEATURES:

1. Double sided PC board with solder mask and silk screen and gold plated contact fingers.
2. Selectable wait states.
3. All address lines & data lines buffered!
4. All sockets included.
5. On card regulators.

KIT INCLUDES ALL PARTS AND SOCKETS (except 2708's). Add $25. for assembled and tested.



DEALER INQUIRIES INVITED!

$69.95 kit

SPECIAL OFFER:

Our 2708's (450NS) are $12.95 when purchased with above kit.

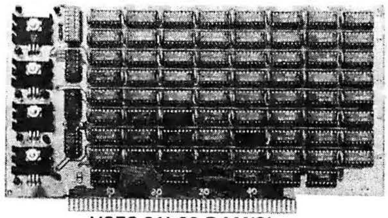
Fully Static!

8K LOW POWER RAM KIT-$149.00

S-100 (Imsai/Altair) Buss Compatible!

KIT FEATURES:

1. Doubled sided PC Board with solder mask and silk screen layout. Gold plated contact fingers.
2. All sockets included.
3. Fully buffered on all address and data lines.
4. Phantom is jumper selectable to pin 67.
5. FOUR 7805 regulators are provided on card.



USES 21L02 RAM'S!

Fully Assembled & Burned In
$179.00
Blank PC Board w/ Documentation
$29.95
Low Profile Socket Set 13.50
Support IC's (TTL & Regulators)
$9.75
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MOTOROLA QUAD OP - AMP
MC 3401. PIN FOR PIN SUB. FOR POPULAR LM 3900.
3 FOR $1

RECTIFIER SPECIAL
1.5 AMP 100PIV
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FULL WAVE BRIDGE
4 AMP. 200 PIV.
69¢ EA. 10 FOR $5.75

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MOTOROLA 7805R VOLTAGE REGULATOR
Same as standard 7805 except 750 MA output. TO—220. 5VDC output.
44c each or 10 for $3.95

450 NS! 2708 EPROMS 450NS!
Now full speed! Prime new units from a major U.S. Mfg. 450 N.S. Access time. 1K x 8. Equiv. to 4-1702 A's in one package.
$15.75 ea. Special Offer: $12.95 each when purchased with our 16K EPROM kit!

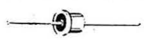
Z—80 PROGRAMMING MANUAL
By Mostek, The major Z-80 second source. The most detailed explanation ever on the working of the Z-80 CPU CHIPS. At least one full page on each of the 158 Z-80 instructions. A MUST reference manual for any user of the Z-80. 300 pages. Just off the press! **A D.R.C. exclusive!** $12.95

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Stud Mount. 1N1187.
35 AMPS. 300 PIV.
Military Quality! $1.19 ea. or 4/$3.50

3 AMP RECTIFIER
1N4721. Axial Lead. 200 PIV.
HEAVY DUTY!
House numbered



4 for $1.00 Metal Case

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2114. The new industry standard. Arranged as 1K x4. Equivalent to 4-21 L02's in 1 package! 18 pin DIP. 2 chips give 1Kx8.
2/$24. 8/$85.

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SLA-1. Common Anode. .33 inch character size. The original high efficiency LED display. 75c ea. or 4 for $2.50

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262.144KHZ. This frequency is 2 to the 18th power. Easily divided down to any power of 2, and even to 1HZ. New by CTS-Knight. A $5. value!
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3 Cell pack, gives 4 volts at 900MAH. Brand new, factory fresh. Each cell is 2/3 "C" size. **$4.50 /pack. Buy 3 packs (12 volts) for $10.95. Limited stock!**

741C OP AMPS
Mini Dip. Prime new units. Has computer Mfg's house number.
12/$2. 100/$15.

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.1 MFD 16V. P.C. leads. Most popular value. By Sprague.
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74LS10 — 33c	74LS175—1.10
74LS20 — 33c	74LS367—75c
74LS73 — 49c	74LS368—85c

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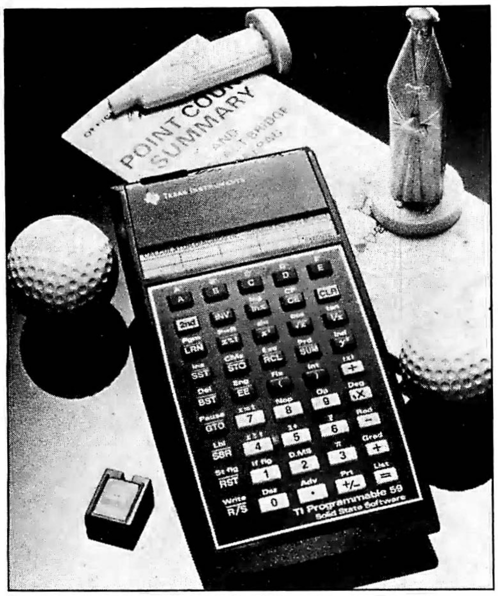
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Circle 39 on inquiry card.

What's New?

SOFTWARE

Leisure Program Library for New TI Calculators



Owners of the Texas Instruments Programmable 58 and 59 calculators (see December 1977 BYTE, page 204) can now enjoy recreational applications of their pocket sized computers with the Solid State Software Leisure Library module. This plug in read only memory unit contains 20 different keystroke programs for golf handicaps, bowling scores, chess ratings, results of deals in duplicate or triplicate bridge, blackjack, acey deucy, craps, NIM, biorhythms, a spacecraft landing and a sea battle game, and other applications. Two programs use the alphabetic and plotting capabilities of the PC-100A printing cradle. The module is $35 from Texas Instruments Inc, Inquiry Answering Service, POB 53 (attn: Leisure Library), Lubbock TX 79408.■

Circle 574 on inquiry card.

FDOS III for iCOM Floppies

FDOS III is a new operating system for 8080 and Z-80 computers using any of iCOM's family of floppy disk drives and interfaces. It is compatible with programs written under FDOS II and has relocatable driver modules for file access. The system includes a string oriented text editor and a relocatable assembler for 8080 or Z-80 programs. Single commands provide for functions such as loading of files, editing and assembly, disk to disk, disk to punch and reader to disk IO. Files may be deleted, renamed or merged to create new files, and may be tagged with attributes to prevent deletion, for example. FDOS III is available from Pertec Computer Corp Microsystems Division, 21111 Erwin St, Woodland Hills CA 91367, (213) 999-2020.■

Circle 575 on inquiry card.

Complete ANSI FORTRAN Compiler for Z-80

This FORTRAN compiler implements full American National Standard FORTRAN IV with a number of extensions, including one and two byte integers, double precision reals, complex, logical and string data types, named COMMON, sequential and direct access IO, and hexadecimal constants. A full library of scientific and string functions is provided, and a linking loader with automatic library search capabilities can link FORTRAN with assembler programs. Generated code can be placed in read only memory, and the package may be used optionally with a planned hardware multiply and divide module for greater speeds of execution. The compiler runs in 24 K bytes of memory in both FDOS IV and CP/M versions. It is available on floppy disk with a user's manual for $349 from Technical Design Labs, Research Park, Bldg H, 1101 State Rd, Princeton NJ 08540, (609) 921-0321.■

Circle 576 on inquiry card.

A FORTRAN Compiler for 8080s

Microsoft, 300 San Mateo NE, Suite 819, Albuquerque NM 87108, has just prepared a brochure on their FORTRAN-80 package, summarizing the features of the compiler for 8080 processors. User's guides for the FORTRAN-80 compiler, MACRO-80 assembler, LINK-80 loader and LIB-80 library packages are available for a price of $20 each. Single user price for the FORTRAN-80 compiler is $500. Versions are said to be available for CP/M, ISIS-II, DTC Microfile and MITS DOS floppy disk operating systems. Write the company for complete details or phone Steve Wood, (505) 262-1486.■

Circle 578 on inquiry card.

Where Do New Product Items Come From?

The information printed in the new products pages of BYTE is obtained from "new product" or "press release" copy sent by the promoters of new products. If in our judgment the neat new whiz-bang gizmo or save the world software package is of interest to the personal computing experimenters and homebrewers who read BYTE, we print the information in some form. We openly solicit such information from manufacturers and suppliers to this marketplace. The information is printed more or less as a first in first out queue, subject to occasional priority modifications.

TDL Version 3.0 "Super BASIC"

Technical Design Labs has introduced Version 3.0 of "Super BASIC," a 12 K BASIC interpreter. Version 3.0 upgrades and supersedes Version 2.1 with improvements in speed and error handling features. Included with the announcement of this improvement was *The 12 K BASIC User's Manual* of approximately 70 pages in length.

Version 3.0 of Super BASIC provides programmable error handling that allows the user to specify special error handling routines processing any error occurring in the basic program without aborting the program. In addition, the ERR and ERL functions are available to provide further flexibility in error processing.

Version 3.0 of Super BASIC allows for the serial input and output of data from the firm's Zapple Monitor defined reader and punch devices. This data may be in ASCII (using INPUT and PRINT commands), or in binary (READ and WRITE). For noncontrolled reader/punch devices, a high speed binary mode is provided (MLOAD and MSAVE). During data input, end of file detection is provided through the ON EOF GO TO construct.

Version 3.0 provides the VARADR function which allows the address of a particular variable to be passed to an assembly language routine through the CALL statement. This allows routines to return data to the calling program.

Version 3.0 also has a provision to associate arbitrary file name strings with LOAD, LOADGO, and SAVE commands.

Version 3.0 of Super BASIC is being released for use with the CP/M disk operating system and is expected to be available soon in a serial paper tape version.

As with all TDL software it is relocatable and uses the monitor's operating system for its IO handling. It comes with the user's manual and occupies 12 K of core. Although primarily designed to run on TDL's Z-80 microcomputer system, it is adaptable to other systems which use the Zilog Z-80 processor. Super BASIC Version 3.0 is on a diskette and is a part of TDL's Software Package A which consists of Version 3.0, The Macro Assembler 2.2, Z-TEL Text Editing Language and the Text Output Processor. This entire package is available now for $249.

For further information contact Technical Design Labs, Research Park, Bldg H, 1101 State Rd, Princeton NJ 08540, (609) 921-0321.■

Circle 577 on inquiry card.

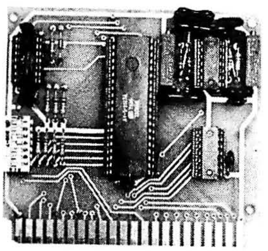
Correction

The price of the Equinox 100 computer system is $799, *not* $699 as we stated in the new product release on page 172 of the January 1978 issue. Our thanks to Linda Hall of Parasitic Engineering for calling this to our attention.

ELECTRONIC SYSTEMS

p.o. box 212 Burlingame CA 94010

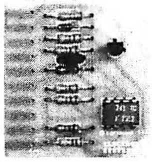
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UART & BAUD RATE GENERATOR

Part no. 101
- Converts serial to parallel and parallel to serial
- Low cost on board baud rate generator
- Baud rates: 110, 150, 300, 600, 1200, and 2400
- Low power drain +5 volts and -12 volts required
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- All characters contain a start bit, 5 to 8 data bits, 1 or 2 stop bits, and either odd or even parity.
- All connections go to a 44 pin gold plated edge connector
- Board only $12.00; with parts $35.00

RS-232/TTL INTERFACE

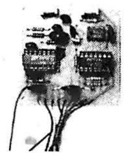


Part no. 232
- Converts TTL to RS-232, and converts RS-232 to TTL
- Two separate circuits
- Requires -12 and +12 volts
- All connections go to a 10 pin gold plated edge connector
- Board only $4.50; with parts $7.00

DC POWER SUPPLY

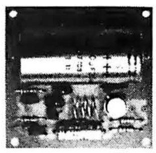


Part no. 6085
- Board supplies a regulated +5 volts at 3 amps., +12,-12, and -5 volts at 1 amp.
- Board has filters, rectifiers, and regulators
- Power required is 8 volts AC at 3 amps., and 24 volts AC C.T. at 1.5 amps.
- Board only $12.50



TAPE INTERFACE

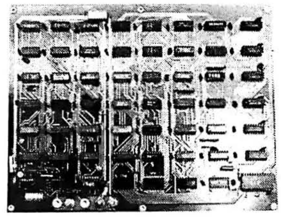
Part no. 111
- Play and record Kansas City Standard tapes
- Converts a low cost tape recorder to a digital recorder
- Works up to 1200 baud
- Digital in and out are TTL-serial
- Output of board connects to mic. in of recorder
- Earphone of recorder connects to input on board
- Requires +5 volts, low power drain
- Board $7.60; with parts $27.50
- No coils



RF MODULATOR

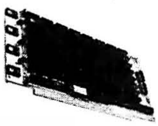
Part no. 107
- Converts video to AM modulated RF, Channels 2 or 3
- Power required is 12 volts AC C.T., or +5 volts DC
- Board $4.50; with parts $13.50

TELEVISION TYPEWRITER



Part no. 106
- Stand alone TVT
- 32 char/line, 16 lines, modifications for 64 char/line included
- Parallel ASCII (TTL) input
- Video output
- 1K on board memory
- Output for computer controlled curser
- Auto scroll
- Non-distructive curser
- Curser inputs: up, down, left, right, home, EOL, EOS
- Scroll up, down
- Requires +5 volts at 1.5 amps, and -12 volts at 30 mA
- Board only $39.00; with parts $145.00

8K STATIC RAM

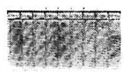


Part no. 300
- 8K Altair bus memory
- Uses 2102 Static memory chips
- Memory protect
- Gold contacts
- Wait states
- On board regulator
- S-100 bus compatible
- Vector input option
- TRI state buffered
- Board only $22.50; with parts $160.00

TIDMA

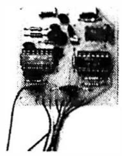
Part no. 112
- Tape Interface Direct Memory Access
- Record and play programs without bootstrap loader (no prom) has FSK encoder/decoder for direct connections to low cost recorder at 625 baud rate, and direct connections for inputs and outputs to a digital recorder at any baud rate.
- S-100 bus compatible
- Comes assembled and tested for $160.00

APPLE I MOTHER BOARD



Part no. 102
- 10 slots – 44 pin (.156) connectors spaced ¾" apart
- Connects to edge connector of computer
- Pin 20 and 22 connects to X & Z for power and ground
- Board has provisions for bypass capacitors
- Board cost $15.00

MODEM



Part no. 109
- Type 103
- Full or half duplex
- Works up to 300 baud
- Originate or Answer
- No coils, only low cost components
- TTL input and output-serial
- Connect 8 ohm speaker and crystal mic. directly to board
- Uses XR FSK demodulator
- Requires +5 volts
- Board $7.60; with parts $27.50

To Order:

VISA master charge

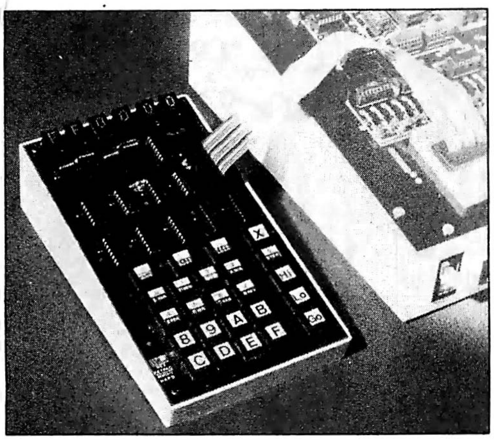
Mention part number and description. For parts kits add "A" to part number. Shipping paid for orders accompanied by check, money order, or Master Charge, BankAmericard, or VISA number, expiration date and signature. Shipping charges added to C.O.D. orders. California residents add 6.5% for tax. Parts kits include sockets for all ICs, components, and circuit board. Documentation is included with all products. Dealer inquiries invited. 24 Hour Order Line: (408) 374-5984. E21

Circle 44 on inquiry card.

What's New?

PERIPHERALS

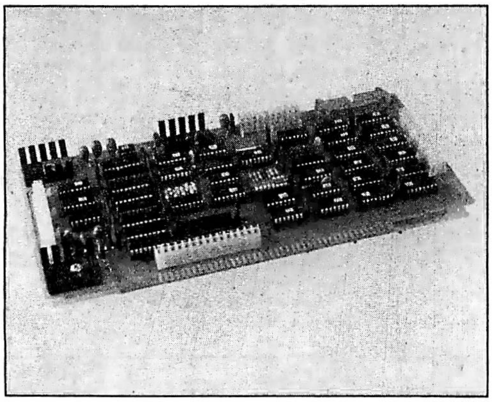
Hexadecimal Keyboard for Micro Designer



Two hexadecimal data entry and display keyboards are now available for the Mini-Micro Designer (MMD-1) microcomputer trainer. 16 hexadecimal digit keys and eight function keys are provided, allowing the user to examine or modify memory or registers and control program execution. Also included is an interconnection cable, a hexadecimal conversion ROM chip to replace the ROM on the MMD-1, and an instruction manual. The MMD/HEX-1 keyboard is $105 in kit form and $125 assembled, while the MMD/HEX-2, which includes two LED hexadecimal digit displays with provision for four additional digit displays, is $165 in kit form or $185 assembled, from E & L Instruments Inc, 61 First St, Derby CT 06418, (203) 735-8774.■

Circle 646 on inquiry card.

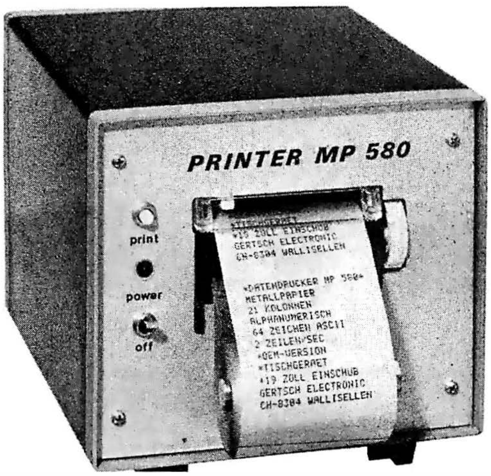
Video Board Offers 80 Character Display and Graphics



This video display board provides two pages of its own display buffer memory, each with 25 rows of 80 characters each. The character set includes 96 upper and lower case ASCII characters with descenders, and 64 graphic display symbols which permit a graphic resolution of 160 horizontal by 75 vertical points. The buffer memory can be loaded at a rate of 400,000 characters per second. A hardware blinking cursor is provided, and a mode register allows other characters to blink. The device consists of two boards, one piggybacked on the other, and occupies one card socket in an Altair (S-100) bus compatible system, but takes up the space of two cards. The board is $349 in kit form or $449 assembled, from Technical Design Labs, Research Park Bldg H, 1101 State Rd, Princeton NJ 08540, (609) 921-0321.■

Circle 647 on inquiry card.

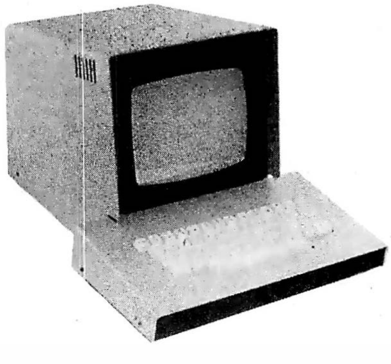
Printer Made in Switzerland



This alphanumeric printer should be of special interest to our European readers. It prints 21 characters per line (with options for 32 or 40 characters) at a rate of 2 lines per second from a set of 64 ASCII characters, in response to a 6 bit parallel, CMOS or TTL compatible input signal. Printing is done on metallized, electrosensitive paper using a mobile head with seven electrodes to form dot matrix characters. Busy, blank, data request and end of line signals are also provided on the 32 pin DIN 41612 connector. Space on a printed circuit board is provided for up to 24 wire wrap sockets, for special interfaces. The MP 580 printer is offered as a module for a 19 inch (48.3 cm) frame for 1380 Swiss francs (about $550), or in a case measuring 135 by 155 by 195 mm for 1480 Swiss francs, from Gertsch & Brütch AG, Hertistrasse 25, CH-8304 Wallisellen SWITZERLAND, telephone 01-830-1255.■

Circle 648 on inquiry card.

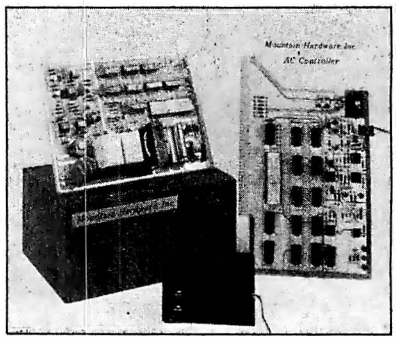
New Low Cost Terminal



The LTL-1k terminal displays 80 characters by 24 lines from a 64 character (upper case only) ASCII character set on a 9 inch diagonal screen with P4 phosphor. A wraparound block see-through cursor is provided with various cursor control functions operated by control codes. The detached keyboard includes 53 keys with 2 key rollover and N key lockout. The terminal communicates over an RS232 interface at any of eight data rates ranging from 110 to 19,200 bps. The LTL-1k is priced at $695 from Cybernex Ltd, POB 9086, 111-2595 Blackwell St, Ottawa, Ontario CANADA K1G 3T8, (613) 741-1540.■

Circle 649 on inquiry card.

Computerize Your House with This Remote Control System



The Introl system allows your computer to remotely control electrical appliances and other equipment by sending signals over the 110 VAC power lines. The system consists of an Altair (S-100) bus compatible AC controller board which can turn on and off up to 64 remote units anywhere in a building. The AC Remote unit has two independently controllable AC sockets which can each turn on and off a 500 W appliance. The computer can also poll the remote unit to check its on or off status. Programs can easily be written in BASIC or assembly language to control remote devices. Future compatible remote units include a dual temperature sensor for solar heating control and other applications, and an 8 input status monitor. In kit form the AC Controller is $149 and each AC Remote unit is $99, from Mountain Hardware Inc, POB 1133, Ben Lomond CA 95005, (408) 336-2495.■

Circle 650 on inquiry card.

DIODES/ZENERS

1N914	100v	10mA	.05
1N4005	600v	1A	.08
1N4007	1000v	1A	.15
1N4148	75v	10mA	.05
1N753A	6.2v	z	.25
1N758A	10v	z	.25
1N759A	12v	z	.25
1N4733	5.1v	z	.25
1N5243	13v	z	.25
1N5244B	14v	z	.25
1N5245B	15v	z	.25

SOCKETS/BRIDGES

8-pin	pcb	.25	ww	.45
14-pin	pcb	.25	ww	.40
16-pin	pcb	.25	ww	.40
18-pin	pcb	.25	ww	.75
22-pin	pcb	.45	ww	1.25
24-pin	pcb	.35	ww	1.10
28-pin	pcb	.35	ww	1.45
40-pin	pcb	.50	ww	1.25
Molex pins	.01	To-3 Sockets		.45
2 Amp Bridge		100-prv		1.20
25 Amp Bridge		200-prv		1.95

TRANSISTORS, LEDS, etc.

2N2222A	NPN (2N2222 Plastic .10)	.15
2N2907A	PNP	.15
2N3906	PNP (Plastic)	.10
2N3904	NPN (Plastic)	.10
2N3054	NPN	.35
2N3055	NPN 15A 60v	.50
T1P125	PNP Darlington	.35
LED Green, Red, Clear, Yellow		.15
D.L.747	7 seg 5/8" High com-anode	1.95
XAN72	7 seg com-anode (Red)	1.25
MAN71	7 seg com-anode (Red)	1.25
MAN3610	7 seg com-anode (Orange)	1.25
MAN82A	7 seg com-anode (Yellow)	1.25
MAN74A	7 seg com-cathode (Red)	1.50
FND359	7 seg com-cathode (Red)	1.25

C MOS

4000	.15
4001	.15
4002	.20
4004	3.95
4006	.95
4007	.35
4008	.95
4009	.45
4010	.45
4011	.20
4012	.20
4013	.40
4014	.95
4015	.90
4016	.35
4017	1.10
4018	1.10
4019	.50
4020	.85
4021	1.00
4022	.85
4023	.25
4024	.75
4025	.30
4026	1.95
4027	.50
4028	.95
4030	.35
4033	1.50
4034	2.45
4035	1.25
4040	1.35
4041	.69
4042	.95
4043	.95
4044	.95
4046	1.75
4049	.45
4050	.45
4066	.95
4069	.40
4071	.35
4081	.70
4082	.45
MC14409	14.50
MC14419	4.85

— T T L —

7400	.15
7401	.15
7402	.20
7403	.20
7404	.15
7405	.25
7406	.35
7407	.55
7408	.25
7409	.15
7410	.10
7411	.25
7412	.30
7413	.35
7414	1.10
7416	.25
7417	.40
7420	.15
7426	.30
7427	.45
7430	.15
7432	.30
7437	.30
7438	.35
7440	.25
7441	1.15
7442	.45
7443	.65
7444	.45
7445	.65
7446	.95
7447	.95
7448	.65
7450	.25
7451	.25
7453	.20
7454	.25
7460	.40
7470	.45
7472	.40
7473	.25
7474	.30
7475	.35
7476	.40
7480	.55
7481	.75
7483	.95
7485	.75
7486	.25
7489	1.35
7490	.55
7491	.95
7492	.95
7493	.35
7494	.75
7495	.60
7496	.80
74100	1.15
74107	.35
74121	.35
74122	.55
74123	.55
74125	.45
74126	.35
74132	1.35
74141	.90
74150	.85
74151	.65
74153	.75
74154	.95
74156	.95
74157	.65
74161	.85
74163	.85
74164	.60
74165	1.50
74166	1.35
74175	.80
74176	1.25
74180	.75
74181	2.25
74182	.95
74190	1.75
74191	1.05
74192	.75
74193	.85
74194	1.25
74195	.95
74196	1.25
74197	1.25
74198	2.35
74221	1.00
74367	.85
75108A	.35
75110	.35
75491	.50
75492	.50
74H00	.15
74H01	.25
74H04	.20
74H05	.20
74H08	.35
74H10	.35
74H11	.35
74H15	.45
74H20	.30
74H21	.25
74H22	.40
74H30	.20
74H40	.25
74H50	.25
74H51	.25
74H52	.15
74H53J	.25
74H55	.20
74H72	.45
74H101	.75
74H103	.75
74H106	.95
74L00	.25
74L02	.25
74L03	.30
74L04	.30
74L10	.30
74L20	.35
74L30	.45
74L47	1.95
74L51	.45
74L55	.65
74L72	.45
74L73	.40
74L74	.45
74L75	.55
74L93	.55
74L123	.85
74S00	.35
74S02	.35
74S03	.30
74S04	.30
74S05	.35
74S08	.35
74S10	.35
74S11	.35
74S20	.35
74S40	.20
74S50	.20
74S51	.25
74S64	.20
74S74	.35
74S112	.60
74S114	.65
74S133	.40
74S140	.55
74S151	.30
74S153	.35
74S157	.75
74S158	.30
74S194	1.05
74S257 (8123)	1.05
74LS00	.25
74LS01	.35
74LS02	.35
74LS04	.30
74LS05	.45
74LS08	.25
74LS09	.35
74LS10	.35
74LS11	.35
74LS20	.25
74LS21	.25
74LS22	.25
74LS32	.40
74LS37	.35
74LS40	.45
74LS42	1.10
74LS51	.50
74LS74	.65
74LS86	.65
74LS90	.95
74LS93	.95
74LS107	.85
74LS123	1.00
74LS151	.95
74LS153	1.20
74LS157	.85
74LS164	1.90
74LS367	.75
74LS368	.75
74C04	.25
74C151	2.25

9000 SERIES

9301	.85	95H03	1.10
9309	.35	9601	.45
9322	.75	9602	.45

MICRO'S, RAMS, CPU'S, ETC.

74S188	3.00
1702A	4.50
MM5314	3.00
MM5316	3.50
2102-1	1.45
2102L-1	1.75
TR1602B	4.50
TMS 4044-45NL	14.50
8080AD	12.00
8T13	1.50
8T23	1.50
8T24	2.00
8T97	1.00
2107B-4, A	4.00
2708	11.50

LINEARS, REGULATORS, etc.

MCT2	.95
8038	3.95
LM201	.75
LM301	.45
LM308 (Mini)	.95
LM309H	.65
LM309K (340K-5)	.85
LM310	1.15
LM311D (Mini)	.75
LM318 (Mini)	.95
LM320K5 (7905)	1.65
LM320K12	1.65
LM320T5	1.65
LM320T12	1.65
LM320T15	1.65
LM324N	.95
LM339	.95
7805 (340T5)	.95
LM340T12	1.00
LM340T15	1.00
LM340T18	1.00
LM340T24	.95
LM340K12	1.65
LM340K15	1.25
LM340K18	1.25
LM340K24	.95
78L05	.75
78L12	.75
78L15	.75
78M05	.75
LM373	2.95
LM380 (8-14 PIN)	.95
LM709 (8, 14 PIN)	.25
LM711	.45
LM723	.50
LM725N	2.50
LM739	1.50
LM741 (8-14)	.25
LM747	1.10
LM1307	1.25
LM1458	.95
LM3900	.50
LM75451	.65
NE555	.50
NE556	.95
NE565	.95
NE566	1.75
NE567	1.35

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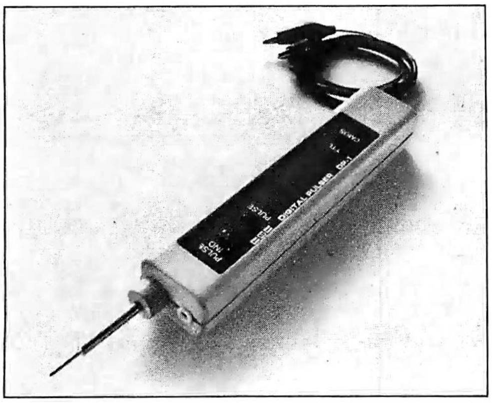
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SPECIAL DISCOUNTS

Total Order	Deduct
$35 - $99	5%
$100 - $300	10%
$301 - $1000	15%
$1000 - Up	20%

What's New?

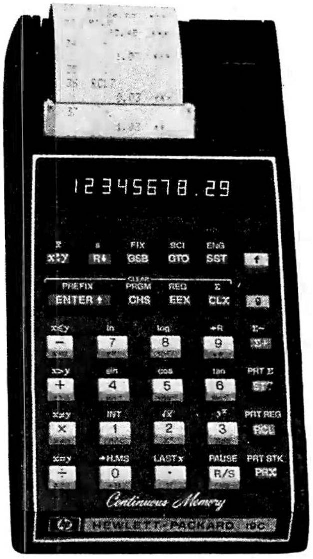
Digital Pulser Delivers High Current



The DP-1 monitors the node being probed and sets itself to deliver a pulse at the other logic level of 50 mA in CMOS mode or 100 mA in TTL mode. The pulse pushbutton sends a single pulse if pushed once, or trains of about 100 pulses per second if held down. Pulses are monitored by an LED. The DP-1 obtains its power from the system under test, and the power connector is a standard phono plug. The DP-1, which is one member of a family of digital troubleshooting hardware which the manufacturer calls The Logical Force, is priced at $74.95 from Continental Specialties Corp,• 44 Kendall St, New Haven CT 06509, (203) 624-3103.■

Circle 657 on inquiry card.

New Pocket Calculator Features Built-in Printer



The HP-19C, a printing version of the HP-29C introduced earlier, is the first pocket calculator with a built-in thermal printer. The calculator also features continuous memory whose contents are not lost when power is turned off. The keystroke programmable HP-19C includes 98 fully merged program steps, 30 data storage registers, and a full set of editing and programming functions such as insertion and deletion of program steps, a total of ten decision tests, ten addressable labels, indirect addressing and three levels of subroutines. The printer can be used to create a permanent record of computed results, to make listings of programs in mnemonic form, and to trace execution during program debugging. The continuous memory feature makes it possible to retain the program, 16 of the 30 data storage registers, and the display register when power is turned off. As many as four keystrokes can be merged into one program step, so that programs of 175 keystrokes can typically be entered. The HP-19C is $345 from Hewlett-Packard Company, 1507 Page Mill Rd, Palo Alto CA 94304, (415) 493-1501.■

Circle 655 on inquiry card.

Use These Cassettes for Reliable Tape IO



The Pilon-30 data cassette incorporates several of the features of higher priced digital cassettes to provide increased reliability for audio cassette recording of digital information at a reasonable price. A principal improvement is a pilon coated pressure pad which assures low friction tape movement across the head and eliminates the typical lint producing fiber pad. The pad leaf spring in ordinary cassettes has been replaced by an energy absorbing foam spring, which dampens oscillations that are sometimes induced in the spring of the tape drags across the pad. The cassette incorporates 150 feet of low noise, low dropout polyester tape in a 5 screw housing which eliminates the case deformation which sometimes occurs when the case is thermo-compression sealed. Data storage capacity is 50,000 bytes at 300 bps or 200,000 bytes at 1200 bps. The Pilon-30 is priced at $2.49 and is available through computer stores or direct (minimum order 5 cassettes) from PerCom Data Company Inc, 318 Barnes, Garland TX 75042, (214) 276-1968.■

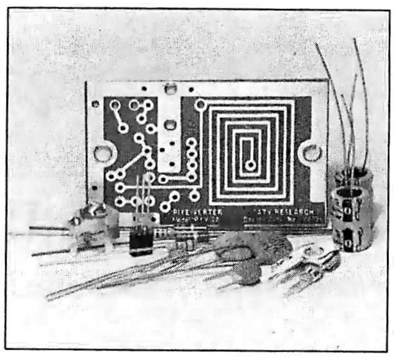
Circle 656 on inquiry card.

Money Management Kit from TI

Continuing its efforts to educate consumers in the use of calculators and computers for everyday problem solving, Texas Instruments has introduced a new personal money management kit, consisting of a 100 page book, *Doing More with Your Money,* and a TI Money Manager calculator. The book is intended for people not highly skilled in financial mathematics, and is organized to give quick answers to common financial problems. The book begins with a chart giving the "answer you need," "information you have" and "page to see." The calculator has several preprogrammed financial routines as well as the common arithmetic, memory and percent functions. The package is $21.95 from Texas Instruments Inc, POB 5012, Dallas TX 75222, (214) 238-2011.■

Circle 651 on inquiry card.

The Classic Kit for TV Set Conversion



Long available for video camera and tape recorder experimenters, the Pixe-Verter has become very popular with computer hobbyists and is now sold by more than 100 computer stores across the US. When modulated by a standard composite video signal between .25 and 5 V, it generates a VHF television signal which can be fed into the antenna terminals of a TV set and used on any black channel between 2 and 6. Because of bandwidth limitations in the TV set, only a limited number of characters per line can be displayed. The device is assembled on a 1.25 by 2.1 inch printed circuit board and requires less than 3 mA at 5 V. The Pixe-Verter is $8.50 postpaid from ATV Research, 13th and Broadway, Dakota City NB 68731, (402) 987-3771.■

Circle 658 on inquiry card.

Circle 60 on inquiry card.

7400N TTL

SN7400N	.16	SN7472N	.39	SN74160N	1.25
SN7401N	.18	SN7473N	.39	SN74161N	.99
SN7402N	.20	SN7474N	.35	SN74162N	1.95
SN7403N	.20	SN7475N	.50	SN74163N	.99
SN7404N	.20	SN7476N	.35	SN74164N	.99
SN7405N	.20	SN7479N	5.00	SN74165N	.99
SN7406N	.35	SN7480N	.50	SN74166N	1.25
SN7407N	.35	SN7482N	.99	SN74167N	3.25
SN7408N	.20	SN7483N	.70	SN74170N	2.10
SN7409N	.25	SN7485N	.89	SN74172N	6.00
SN7410N	.20	SN7486N	.39	SN74173N	1.50
SN7411N	.30	SN7488N	3.50	SN74174N	1.25
SN7412N	.35	SN7489N	2.49	SN74175N	.99
SN7413N	.69	SN7490N	.45	SN74176N	.79
SN7414N	.70	SN7491N	.75	SN74177N	.79
SN7416N	.35	SN7492N	.49	SN74179N	2.49
SN7417N	.35	SN7493N	.49	SN74180N	.99
SN7420N	.20	SN7494N	.79	SN74181N	2.49
SN7421N	.39	SN7495N	.79	SN74182N	.95
SN7422N	.49	SN7496N	.79	SN74184N	1.95
SN7423N	.37	SN7497N	3.00	SN74185N	1.95
SN7425N	.29	SN74100N	1.25	SN74186N	15.00
SN7426N	.29	SN74107N	.39	SN74187N	6.00
SN7427N	.37	SN74109N	.95	SN74188N	3.95
SN7429N	.42	SN74116N	1.95	SN74190N	1.79
SN7430N	.25	SN74121N	.39	SN74191N	1.25
SN7432N	.25	SN74122N	.39	SN74192N	.89
SN7437N	.35	SN74123N	.50	SN74193N	.89
SN7438N	.35	SN74125N	.60	SN74194N	1.25
SN7439N	.25	SN74126N	.60	SN74195N	.75
SN7440N	.21	SN74132N	1.25	SN74196N	1.00
SN7441N	.89	SN74136N	.95	SN74197N	1.00
SN7442N	.69	SN74141N	1.15	SN74198N	1.75
SN7443N	.75	SN74142N	2.95	SN74199N	1.75
SN7444N	.75	SN74143N	3.25	SN74200N	5.59
SN7445N	.75	SN74144N	3.00	SN74251N	1.79
SN7446N	.89	SN74145N	1.15	SN74279N	.90
SN7447N	.69	SN74147N	2.35	SN74283N	2.25
SN7448N	.89	SN74148N	2.00	SN74284N	6.00
SN7450N	.25	SN74150N	1.25	SN74285N	6.00
SN7451N	.25	SN74151N	.79	SN74365N	.75
SN7453N	.25	SN74153N	.89	SN74366N	.75
SN7454N	.25	SN74154N	1.25	SN74367N	.75
SN7459A	.25	SN74155N	.89	SN74368N	.75
SN7460N	.25	SN74156N	.89	SN74390N	2.25
SN7470N	.45	SN74157N	.89	SN74393N	2.25

20% Discount for 100 Combined 7400's

CMOS

CD4000	.23	CD4044	.89	CD4520	1.29
CD4001	.23	CD4046	1.79	MC14562	14.50
CD4002	.23	CD4047	2.50	CD4566	2.25
CD4006	1.19	CD4048	1.35	MC14583	3.50
CD4007	.25	CD4049	.49	**74C00 Series**	
CD4009	.49	CD4050	.49	74C00	.39
CD4010	.49	CD4051	1.19	74C02	.55
CD4011	.23	CD4053	1.19	74C04	.75
CD4012	.25	CD4056	1.49	74C10	.65
CD4013	.39	CD4059	9.95	74C14	3.00
CD4014	1.39	CD4060	1.49	74C20	.65
CD4015	1.19	CD4066	.79	74C30	.65
CD4016	.49	CD4068	.39	74C42	2.15
CD4017	1.19	CD4069	.45	74C73	1.50
CD4018	.99	CD4070	.55	74C74	1.15
CD4019	.49	CD4071	.23	74C89	4.00
CD4020	1.19	CD4072	.49	74C90	3.00
CD4021	1.39	CD4076	1.39	74C93	2.00
CD4022	1.19	CD4081	.23	74C95	2.00
CD4023	.23	CD4082	.23	74C107	1.25
CD4024	.79	CD4098	2.49	74C151	2.90
CD4025	.23	MC14409	14.95	74C154	3.00
CD4026	2.25	MC14410	14.95	74C157	2.15
CD4027	.69	MC14411	14.95	74C160	3.25
CD4028	.89	MC14419	4.95	74C161	3.25
CD4029	1.19	MC14506	.75	74C163	3.00
CD4030	.49	MC14507	.99	74C164	3.25
CD4035	.99	CD4508	3.95	74C173	2.60
CD4040	1.19	CD4510	1.39	74C193	2.75
CD4041	1.25	CD4511	1.29	74C195	2.75
CD4042	.99	CD4515	2.95	80C95	1.50
		CD4518	1.29	80C97	1.50

LINEAR

LM300H	.80			LM739N	1.19
LM301H	.35	LM340T-8	1.25	LM741CH	.35
LM301CN	.35	LM340T-12	1.25	LM741CN	.35
LM302H	.75	LM340T-15	1.25	LM741-14N	.39
LM304H	1.00	LM340T-18	1.25	LM747H	.79
LM305H	.60	LM340T-24	1.25	LM747N	.79
LM307CN	.35	LM350N	1.00	LM748H	.39
LM308H	1.00	LM351CN	.65	LM748N	.39
LM308CN	1.00	78MG	1.75	LM1303N	.90
LM309H	1.10	LM370N	1.15	LM1304N	1.19
LM309K	1.25	LM373N	3.25	LM1305N	1.40
LM310CN	1.15	LM377N	4.00	LM1307N	.85
LM311H	.90	LM380N	1.25	LM1310N	2.95
LM311N	.90	LM380CN	.99	LM1351N	1.65
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LM320T-15	1.25	NE561B	5.00	LM5556N	1.85
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74LS10	.29	74LS86	.49	74LS164	1.95
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74LS14	1.75	74LS92	.89	74LS181	3.69
74LS20	.29	74LS93	.89	74LS190	2.49
74LS26	.39	74LS95	1.50	74LS191	2.49
74LS27	.39	74LS96	1.89	74LS192	2.49
74LS28	.39	74LS107	.59	74LS193	2.49
74LS30	.29	74LS112	.59	74LS194	1.69
74LS32	.39	74LS123	1.25	74LS195	1.89
74LS40	.39	74LS132	1.25	74LS253	1.75
74LS42	1.25	74LS136	.59	74LS257	1.75
74LS47	1.25	74LS138	1.25	74LS260	.55
74LS51	.29	74LS139	1.25	74LS279	.79
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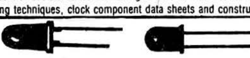
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MAN 3	Common Cathode-red	.125	4/$1	MAN 6730	Common Anode-red ±1	.560	.79
MAN 4	Common Cathode-red	.187	1.95	MAN 6740	Common Cathode-red-D.D.	.560	.79
MAN 52	Common Anode-green	.300	1.00	MAN 6750	Common Cathode-red ±1	.560	.79
MAN 71	Common Anode-red	.300	1.25	MAN 6760	Common Anode-red	.560	.79
MAN72	Common Anode-red	.300	.79	MAN 6780	Common Cathode-red	.560	.79
MAN 74	Common Cathode-red	.300	1.50	DL701	Common Anode-red ±1	.300	1.00
MAN 81	Common Anode-yellow	.300	.79	DL702	Common Cathode-red	.300	1.25
MAN 82	Common Anode-yellow	.300	.79	DL704	Common Cathode-red	.300	.99
MAN 84	Common Cathode-yellow	.300	.79	DL707	Common Anode-red	.300	.99
MAN 3620	Common Anode-orange	.300	.79	DL741	Common Anode-red	.600	1.49
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MAN 3640	Common Cathode-orange	.300	.79	DL747	Common Anode-red	.600	1.49
MAN 4610	Common Anode-orange	.300	.79	DL749	Common Cathode-red ±1	.630	1.95
MAN 4640	Common Cathode-orange	.400	.79	DL750	Common Cathode-red	.600	1.49
MAN 4710	Common Anode-red ±1	.400	.79	DL338	Common Cathode-red	.110	3/1.00
MAN 4730	Common Anode-red	.400	1.00	FND70	Common Cathode (FND359)	.250	.69
MAN 4740	Common Cathode-red	.400	.79	FND503	Common Cathode (FND500)	.500	.99
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MAN 6640	Common Cathode-orange-D.D.	.560	.79	5082-7304	Overrange character (±1)	.600	15.00
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CA3039	1.35	CA3089	3.75
CA3046	1.30	CA3091	3.50
CA3053	1.50	CA3102	2.95
CA3059	3.25	CA3123	2.15
CA3060	3.25	CA3130	1.39
CA3080	.85	CA3140	1.25
CA3081	2.00	CA3401	.49
		CA3600	1.75

EXAR

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	1-24	25-49	50-100		1-24	25-49	50-100
8 pin	$.17	.16	.15	24 pin	$.38	.37	.36
14 pin	.20	.19	.18	28 pin	.45	.44	.43
16 pin	.22	.21	.20	36 pin	.60	.59	.58
18 pin	.29	.28	.27	40 pin	.63	.62	.61
22 pin	.37	.36	.35				

SOLDERTAIL STANDARD (TIN)



	1-24	25-49	50-100		1-24	25-49	50-100
14 pin	$.27	.25	.24	28 pin	$ .99	.90	.81
16 pin	.30	.27	.25	36 pin	1.39	1.26	1.15
18 pin	.35	.32	.30	40 pin	1.59	1.45	1.30
24 pin	.49	.45	.42				

SOLDERTAIL STANDARD (GOLD)



	1-24	25-49	50-100		1-24	25-49	50-100
8 pin	$.30	.27	.24	24 pin	$ .70	.63	.57
14 pin	.35	.32	.29	28 pin	1.10	1.00	.90
16 pin	.38	.35	.32	36 pin	1.75	1.40	1.26
18 pin	.52	.47	.43	40 pin	1.75	1.59	1.45

WIRE WRAP SOCKETS (GOLD) LEVEL #3



	1-24	25-49	50-100		1-24	25-49	50-100
8 pin	$.40	.38	.35	22 pin	.95	.85	.75
10 pin	.45	.41	.37	24 pin	$1.05	.95	.85
14 pin	.39	.38	.37	28 pin	1.40	1.25	1.10
16 pin	.43	.42	.41	36 pin	1.59	1.45	1.30
18 pin	.75	.68	.62	40 pin	1.75	1.55	1.40

50 PCS. RESISTOR ASSORTMENTS $1.75 PER ASST.

		10 OHM	12 OHM	15 OHM	18 OHM	22 OHM	
ASST. 1	5 ea.	27 OHM	33 OHM	39OHM	47 OHM	56 OHM	1/4 WATT 5% = 50 PCS.
		68 OHM	82 OHM	100 OHM	120 OHM	150OHM	
ASST. 2	5 ea.	180 OHM	220 OHM	270 OHM	330 OHM	390 OHM	1/4 WATT 5% = 50 PCS.
		470 OHM	560 OHM	680OHM	820OHM	1K	
ASST. 3	5 ea.	1.2K	1.5K	1.8K	2.2K	2.7K	1/4 WATT 5% = 50 PCS.
		3.3K	3.9K	4.7K	5.6K	6.8K	
ASST. 4	5 ea.	8.2K	10K	12K	15K	18K	1/4 WATT 5% = 50 PCS.
		22K	27K	33K	39K	47K	
ASST..5	5 ea.	56K	68K	82K	100K	120K	1/4 WATT 5% = 50 PCS.
		150K	180K	220K	270K	330K	
ASST. 6	5 ea.	390K	470K	560K	680K	820K	1/4 WATT 5% = 50 PCS.
		1M	1.2M	1.5M	1.8M	2.2M	
ASST. 7	5 ea.	2.7M	3.3M	3.9M	4.7M	5.6M	1/4 WATT 5% = 50PCS.

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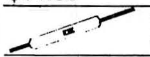
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SW7432	1.50	12.00	110.00	SW74105	2.20	19.00	180.00
SW7437	1.50	12.00	110.00	SW74107	2.20	19.00	180.00
SW7438	1.50	12.00	110.00	SW74121	2.20	19.00	180.00
SW7440	1.20	9.00	80.00	SW74123	2.50	22.00	200.00
SW7443	3.50	31.00	300.00	SW74145	5.50	51.00	500.00
SW7444	3.50	31.00	300.00	SW74150	6.90	66.00	650.00
SW7445	3.50	31.00	300.00	SW74151	3.50	31.00	300.00
SW7446	4.00	36.00	350.00	SW74153	4.00	36.00	350.00
SW7450	1.20	9.00	80.00	SW74156	4.00	36.00	350.00
SW7453	1.20	9.00	80.00	SW74180	4.50	41.00	400.00
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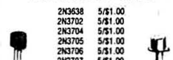
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1N752	5.6	400m	4/1.00	1N4007	1000 PIV	1 AMP	10/1.00
1N753	6.2	400m	4/1.00	1N3600	50	200m	6/1.00
1N754	6.8	400m	4/1.00	1N4148	75	10m	15/1.00
1N959	8.2	400m	8/1.00	1N4154	35	10m	12/1.00
1N965B	15	400m	4/1.00	1N4305	75	25m	20/1.00
1N5232	5.6	500m	28	1N4734	5.6	1w	28
1N5234	6.2	500m	28	1N4735	6.2	1w	28
1N5235	6.8	500m	28	1N4736	6.8	1w	28
1N5236	7.5	500m	28	1N4738	8.2	1w	28
1N456	25	40m	6/1.00	1N4742	12	1w	28
1N458	150	7m	6/1.00	1N4744	15	1w	28
1N485A	180	10m	6/1.00	1N1183	50 PIV	35 AMP	1.60
1N4001	50 PIV	1 AMP	12/1.00	1N1184	100 PIV	35 AMP	1.70
1N4002	100 PIV	1 AMP	12/1.00	1N1185	150 PIV	35 AMP	1.50
1N4003	200 PIV	1 AMP	12/1.00	1N1186	200 PIV	35 AMP	1.80
1N4004	400 PIV	1 AMP	12/1.00	1N1188	400 PIV	35 AMP	3.00

SCR AND FW BRIDGE RECTIFIERS

C36D	15A @ 400V	SCR	$1.95
C38M	35A @ 200V	SCR	1.95
2N2328	1.6A @ 200V	SCR	.50
MDA 980-1	12A @ 50V	FW BRIDGE REC.	1.95
MDA 980-3	12A @ 200V	FW BRIDGE REC.	1.95

TRANSISTORS



MPS A05	.30			PN4250	4/$1.00
MPS A06	5/$1.00			2N4400	4/$1.00
2N918	4/$1.00			2N4401	4/$1.00
2N2219A	3/$1.00	2N3638	5/$1.00	2N4402	4/$1.00
2N2221	4/$1.00	2N3702	5/$1.00	2N4403	4/$1.00
2N2222A	5/$1.00	2N3704	5/$1.00	2N4409	5/$1.00
2N2369	5/$1.00	2N3705	5/$1.00	2N5086	4/$1.00
2N2369A	4/$1.00	2N3706	5/$1.00	2N5087	4/$1.00
2N2484	4/$1.00	2N3707	5/$1.00	2N5088	4/$1.00
2N2906A	4/$1.00	2N3711	5/$1.00	2N5089	4/$1.00
2N2907A	5/$1.00	2N3724	$ .65	2N5129	5/$1.00
2N2925	5/$1.00	2N3725	$1.00	2N5138	5/$1.00
2N3035	2/$1.00	2N3772	$2.25	2N5139	5/$1.00
2N3055	$ .89	2N3903	5/$1.00	2N5209	5/$1.00
MJE2955	$1.25	2N3904	4/$1.00	2N5210	5/$1.00
MJE3055	$1.00	2N3905	4/$1.00	2N5432	$2.00
2N3392	5/$1.00	2N3906	4/$1.00	2N5449	3/$1.00
2N3398	5/$1.00	2N4013	3/$1.00	2N5951	5/$1.00
PN3567	3/$1.00	2N4014	3/$1.00	C106B1SCR	2/$1.00
PN3568	4/$1.00	2N4123	6/$1.00	40409	$1.75
PN3569	4/$1.00	PN4249	4/$1.00	40410	$1.75

CAPACITOR CORNER

50 VOLT CERAMIC DISC CAPACITORS

	1-9	10-49	50-100		1-9	10-49	50-100
10 pf	.05	.04	.03	.001µF	.05	.04	.035
22pf	.05	.04	.03	.0047µF	.05	.04	.035
47pf	.05	.04	.03	.01µF	.05	.04	.035
100pf	.05	.04	.03	.022µF	.08	.05	.04
220pf	.05	.04	.03	.047µF	.06	.05	.04
470pf	.05	.04	.035	.1µF	.12	.09	.075
100 VOLT MYLAR FILM CAPACITORS							
.001mf	.12	.10	.07	.022mf	.13	.11	.08
.0022	.12	.10	.07	.047mf	.21	.17	.13
.0047mf	.12	.10	.07	.1mf	.27	.23	.17
.01mf	.12	.10	.07	.22mf	.33	.27	.22
+20% DIPPED TANTALUMS (SOLID) CAPACITORS							
.1/35V	.28	.23	.17	1.5/35V	.30	.26	.21
.15/35V	.28	.23	.17	2.2/25V	.31	.27	.22
.22/35V	.28	.23	.17	3.3/25V	.31	.27	.22
.33/35V	.28	.23	.17	4.7/25V	.32	.28	.23
.47/35V	.28	.23	.17	6.8/25V	.36	.31	.25
.68/35V	.28	.23	.17	10/25V	.40	.35	.29
1.0/35V	.28	.23	.17	15/25V	.63	.50	.40
MINIATURE ALUMINUM ELECTROLYTIC CAPACITORS							
Axial Lead				**Radial Lead**			
.47/50V	.15	.13	.10	.47/25V	.15	.13	.10
1.0/50V	.16	.14	.11	.47/50V	.16	.14	.11
3.3/50V	.14	.13	.10	1.0/16V	.15	.13	.10
4.7/25V	.16	.14	.12	1.0/25V	.18	.14	.11
10/25V	.15	.13	.10	1.0/50V	.18	.14	.11
10/50V	.16	.14	.12	4.7/16V	.15	.13	.10
22/25V	.17	.15	.12	4.7/25V	.15	.13	.10
22/50V	.24	.20	.18	4.7/50V	.16	.14	.11
47/25V	.19	.17	.15	10/16V	.14	.12	.09
47/50V	.25	.21	.19	10/25V	.15	.13	.10
100/25V	.24	.20	.18	10/50V	.16	.14	.12
100/50V	.35	.30	.28	47/50V	.24	.21	.19
220/25V	.32	.28	.25	100/16V	.19	.15	.14
220/50V	.45	.41	.38	100/25V	.24	.20	.18
470/25V	.33	.29	.27	100/50V	.35	.30	.28
1000/16V	.55	.50	.45	220/16V	.23	.17	.16
2200/16V	.70	.62	.55	470/25V	.31	.28	.26

SOCKET JUMPERS

Mates with two rows of .025" sq. or dia. posts on patterns of .100" centers and shielded receptacles. Probe access holes in back. Choice of 6" or 18" length.

Part No.	No. of Contacts	Length	Price
924003-18R	26	18"	$ 5.38 ea.
924003-06R	26	6"	4.78 ea.
924005-18R	40	18"	8.27 ea.
924005-06R	40	6"	7.33 ea.
924006-18R	50	18"	10.31 ea.
924006-06R	50	6"	9.15 ea.

JUMPER HEADERS

Solder to PC boards for instant plug-in access via socket-connector jumpers. .025" sq. posts. Choice of straight or right angle.

Part No.	No. of Posts	Angle	Price
923863-R	26	straight	$1.28 ea.
923873-R	26	right angle	1.52 ea.
923865-R	40	straight	1.94 ea.
923875-R	40	right angle	2.30 ea.
923866-R	50	straight	2.36 ea.
923876-R	50	right angle	2.82 ea.

INTRA-CONNECTOR

Provides both straight and right angle functions. Mates with standard .10" x .10" dual row connectors (i.e. 3m, Ainsley, etc.) Permits quick testing of inaccessible lines.

Part No.: 922576-26 No. of contacts: 26 Price $6.90 ea.

INTRA-SWITCH

Permits instant line-by-line switching for diagnostic or QA testing. Switches actuated with pencil or probe tip. Mates with standard .10" x .10" dual-row connectors. Low profile design. Switch buttons recessed to eliminate accidental switching.

Part No.: IS-26 No. of contacts: 26 Price $13.80 ea.

CRYSTALS

THESE FREQUENCIES ONLY

Part #	Frequency	Case/Style	Price
CY1A	1.000 MHz	HC33/U	$5.95
CY2A	2.000 MHz	HC33/U	$5.95
CY2.01	2.010 MHz	HC33/U	$ .99
CY3A	4.000 MHz	HC18/U	$4.95
CY7A	5.000 MHz	HC18/U	$4.95
CY12A	10.000 MHz	HC18/U	$4.95
CY14A	14.31818 MHz	HC18U	$4.95
CY19A	18.000 MHz	HC18/U	$4.95
CY22A	20.000 MHz	HC18/U	$4.95
CY30B	32.000 MHz	HC18/U	$4.95

CONNECTORS

PRINTED CIRCUIT EDGE-CARD

.156 Spacing-Tin-Double Read-Out
Bifurcated Contacts — Fits .054 to .070 P.C. Cards

15/30	PINS (Solder Eyelet)	$1.95
18/36	PINS (Solder Eyelet)	$2.49
22/44	PINS (Solder Eyelet)	$2.95
50/100A (.100 Spacing)	PINS (Wire Wrap)	$6.95

25 PIN-D SUBMINATURE (RS232)

DB25P	PLUG	$3.25
DB25S	SOCKET	$4.95
DB51226-1	COVER FOR 25S/25P	$1.75

LOTS OF POTS



Untested ⅜" square Spectrol Trimpots
Single-turn Printed Circuit Potentiometers

GB134	3 ea. of:	10-20-25-50 100-200-250-500 ohm	= 24 pcs.	$2.95
GB135	3 ea. of:	1K-2K-2.5K-5K 10K-20K-25K-50K	= 24 pcs.	$2.95
GB136	3 ea. of:	100K-200K-250K-500K 1Meg-2Meg-2.5Meg-5Meg	= 24 pcs.	$2.95

(Values subject to substitution within each group.)

'EXTRA SAVINGS' Buy all 3 (GB134, 135 & 136) for only $7.49

SWITCHES

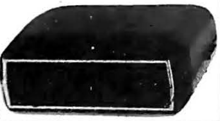
¼" mounting holes

	Part			1-9	10+
TOGGLE (sub-minature)	JMT121	SPDT	on-off-on	$1.95	$1.43
	JMT123	SPDT	on-none-on	1.65	1.21
	JMT221	DPDT	on-off-on	2.55	1.87
	JMT223	DPDT	on-none-on	2.15	1.58
TOGGLE (Printed Circuit)	MPC121	SPDT	on-off-on	$2.05	$1.53
	MPC123	SPDT	on-none-on	1.75	1.31
	MPC221	DPDT	on-off-on	2.65	1.97
	MPC223	DPDT	on-none-on	2.25	1.68
PUSH BUTTON	PB123	SPDT	maintained	1.95	1.47
	PB126	SPDT	momentary	1.95	1.47
PUSH BUTTON Minature	MS102	DPST	momentary open	.35	.30
	MS103	SPST	momentary closed	.35	.30
DIPSWITCH SPST	206-4	8 pin dip	4 switch	1.75	1.65
	206-7	14 pin dip	7 switch	1.95	1.85
	206-8	16 pin dip	8 switch	2.25	2.15

1/16 VECTOR BOARD

	0.1" Hole Spacing Part No	P-Pattern L	P-Pattern W	Price 1-9	Price 10up
PHENOLIC	64P44 062XXXP	4.50	6.50	1.72	1.54
	169P44 062XXXP	4.50	17.00	3.69	3.32
EPOXY GLASS	64P44 062WE	4.50	6.50	2.07	1.86
	84P44 062WE	4.50	8.50	2.56	2.31
	169P44 062WE	4.50	17.00	5.04	4.53
	169P84 062WE	8.50	17.00	9.23	8.26
EPOXY GLASS COPPER CLAD	169P44 062WEC1	4.50	17.00	6.80	6.12

INSTRUMENT/ CLOCK CASE



Injection molded unit.
Complete with red bezel.
4½" x 4" x 1-9/16".

$3.49

MICROPROCESSOR COMPONENTS

8080A	CPU	$10.95	CDP1802	CPU	$19.95
8212	8 Bit Input/Output	4.95	MC6800	8 Bit MPU	19.95
8214	Priority Interrupt Control	7.95	MC6820	Periph. Interface Adapter	7.95
8216	Bi-Directional Bus Driver	4.95	MC6810AP1	128 x 8 Static RAM	5.95
8224	Clock Generator/Driver	5.95	MC6830L8	1024 x 8 Bit ROM	15.00
8228	System Controller Bus Driver	5.95	Z80	CPU	24.95

CPU'S

8080A	Super8008	$10.95
2650	8 Bit MPU	26.50
P8085	CPU	29.95

SR'S

2504	1024 Dynamic	$ 3.95
2518	Hex 32 BIT	7.00
2519	Hex 40 BIT	4.00
2522	Dual 132 Bit SSR	2.95
2524	512 Dynamic	.99
2525	1024 Dynamic	3.00
2527	Dual 256 BIT	3.95
2529	Dual 512 BIT	4.00
2532	Quad 80 BIT	3.95
2533	1024 Static	5.95
3341	Fifo	6.95
74LS670	16 x 4 Reg	3.95

UART'S

AY-5-1013	30K Baud	$ 5.95

ROM'S

2513(2140)	Char. Gen.-upper case	$ 9.95
2513(3021)	Char. Gen -lowercase	9.95
2516	Char. Gen.	10.95
MM5230	2048 BIT (512 x 4 on 256 x 8)	1.95

MM5262	2K x 1	Dynamic RAM	3 for 1.00

RAM'S

1101	256 x 1	Static	$ 1.49
2101	255 x 4	Static	5.95
2102	1024 x 1	Static	1.75
2107/5280	4096 x 1	Dynamic	4.95
2111	256 x 4	Static	6.95
TMS4044-45NL	4K	Static	14.95
7489	16 x 4	Static	2.49
8101	256 x 4	Static	5.95
8111	256 x 4	Static	6.95
8599	16 x 4	Static	3.49
21L02/91L02	1024 x 1	Static	2.25
74200	256 x 1	Static	6.95
93421	256 x 1	Static	2.95
UPD414(2104)	4K	Dynamic 16 Pin	5.95
UPD416	16K	Dynamic	49.95

PROMS

1702A	2048	Famos	$ 5.95
5203	2048	Famos	14.95
82S23	32 x 8	Open C	5.00
82S123	32 x 8	Tristate	5.00
74S287	1024	Static	7.95
3601	256 x 4	Fast	3.95
2708	8K	Eprom	10.95
2716	16K	Eprom	29.95
6301-1	1024	Tri-State Bipolar	3.49
6330-1	256	Open Collector Bipolar	2.95

SPECIAL REQUESTED ITEMS

FCM3817	$5.00	11C90	19.95	7205	19.95	9368	3.95
AY-3-8500-1	7.50	4N33	3.95	ICM7045	24.95	LD110/111	25.00/set
AY-5-9100	17.50	8T20	7.50	ICM7207	7.50	95H90	11.95
AY-5-9200	14.95	8T97	2.00	ICM7208	22.00	MC3061P	3.50
AY-5-9500	4.95	HD0165	7.95	ICM7209	7.50	MC4016 (74416)	7.50
AY-5-2376	14.95	MCM6571	13.50	MK50240	17.50	MC1408L7	8.95
9374	1.95	MCM6574	13.50	DS0026CH	3.75	MC1408L8	9.95
82S115	25.00	MCM6575	13.50	TIL308	10.50	74C922	9.95

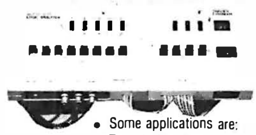
CLOCK CHIPS

MM5309	$9.95
MM5311	4.95
MM5312	4.95
MM5314	4.95
MM5316	6.95
MM5318	9.95
MM5369	2.95
MM5841	9.95
CT7001	5.95

PARATRONICS

Featured on February's Front Cover of Popular Electronics

Logic Analyzer Kit Model 100A



$229.00/kit

- Analyzes any type of digital system
- Checks data rates in excess of 8 million words per second
- Trouble shoot TTL, CMOS, DTL, RTL, Schottky and MOS families
- Displays 16 logic states up to 8 digits wide
- See ones and zeros displayed on your CRT, octal or hexadecimal format
- Tests circuits under actual operating conditions
- Easy to assemble — comes with step-by-step construction manual which includes 80 pages on logic analyzer operation.

(Model 100A Manual - $4.95)

- Some applications are:
  - — Troubleshooting microprocessor address, instruction, and data flow
  - — Examine contents of ROMS
  - — Tracing operation of control logic
  - — Checking counter and shift register operation
  - — Monitoring I/O sequences
  - — Verifying proper system operations during testing

PARATRONICS TRIGGER EXPANDER - Model 10

Adds 16 additional bits. Provides digital delay and qualification of input clock and 24-bit trigger word. — Connects direct to Model 100A for integrated unit).

Model 10 Kit - $229.00
Baseplate — $9.95
Model 10 Manual — $4.95

B+K PRECISION 3½-Digit Portable DMM



- Overload Protected
- .3" high LED Display
- Battery or AC operation
- Auto Zeroing
- 1mv, 1Va, 0.1 ohm resolution
- Overange reading
- 10 meg input impendence
- DC Accuracy 1% typical

Ranges: DC Voltage ±0-1000V/ AC Voltage: 0-1000V
Freq. Response: 50-400 HZ
DC/AC Current: 0-100mA
Resistance 0-10 meg ohm
Size: 6.4" x 4.4" x 2"

Model 2800 $99.95

Comes with test leads, operating manual and spare fuse.

Accessories:

AC Adapter BC-28	$9.00
Rechargeable Batteries BP-26	20.00
Carrying Case LC-28	7.50

CSC 100 MHz 8-Digit Counter

- 20 Hz-100 MHz Range
- .6" LED Display
- Crystal-controlled timebase
- Fully Automatic
- Portable — completely self-contained
- Size — 1.75" x 7.38" x 5.63"
- Four power souces, i.e. batteries, 110 or 220V with charger 12V with auto lighter adapter and external 7.2-10V power supply

MAX-100 $134.95



ACCESSORIES FOR MAX 100:

Mobile Charger Eliminator use power from car battery — Model 100 — CLA $3.95
Charger/Eliminator use 110 V AC — Model 100 — CAI $9.95

CONTINENTAL SPECIALTIES

PROTO BOARD 6

$15.95
(6" long X 4" wide)



Other CS Proto Boards

PB100 - 4.5" x 6"	$ 19.95
PB101 - 5.8" x 4.5"	29.95
PB102 - 7" x 4.5"	39.95
PB103 - 9" x 6"	59.95
PB104 - 9.5" x 8"	79.95
PB203 - 9.75 x 6½ x 2¾	80.00
PB203A - 9.75 x 6½ x 2¾ (includes power supply)	129.95

PROTO CLIPS

14 PIN	$4.50
16 PIN	4.75
24 PIN	8.50
40 PIN	13.75

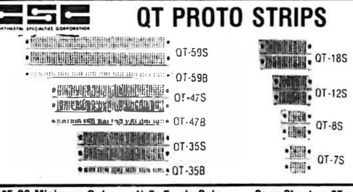
DESIGN MATES

DM1 - Circuit Designer $69.95
DM2 - Function Generator $74.95
DM3 - RC Bridge $74.95

LOGIC MONITOR

for DTL, HTL, TTL or CMOS Devices **$84.95**

CSC QT PROTO STRIPS



QT type	#holes	price
QT-59S	590	12.50
QT-59B	bus strip	2.50
QT-47S	470	10.00
QT-47B	bus strip	2.25
QT-35S	350	8.50
QT-35B	bus strip	2.00
QT-18S	180	4.75
QT-12S	120	3.75
QT-8S	80	3.25
QT-7S	70	3.00

Experimentor 300	$ 9.95
Experimentor 600	$10.95

$5.00 Minimum Order — U.S. Funds Only
California Residents — Add 6% Sales Tax

Spec Sheets - 25¢ — Send 35¢ Stamp for 1978 Catalog
Dealer Information Available

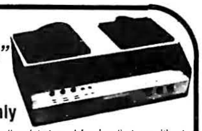
NOW OPEN SATURDAYS

James ELECTRONICS

1978 CATALOG NOW AVAILABLE

1021-A HOWARD AVE., SAN CARLOS, CA. 94070
PHONE ORDERS WELCOME — (415) 592-8097
Advertised Prices Good Thru April

The Incredible "Pennywhistle 103"



$129.95 Kit Only

The Pennywhistle 103 is capable of recording data to and from audio tape without critical speed requirements for the recorder and it is able to communicate directly with another modem and terminal for telephone "hamming" and communications for the deaf. In addition, it is free of critical adjustments and is built with non-precision, readily available parts.

Data Transmission Method .....Frequency-Shift Keying, full-duplex (half-duplex selectable)
Maximum Data Rate ....300 Baud.
Data Format ....Asynchronous Serial (return to mark level required between each character)
Receive Channel Frequencies ...2025 Hz for space; 2225 Hz for mark.
Transmit Channel Frequencies ..Switch selectable: Low (normal) = 1070 space, 1270 mark; High = 025 space, 2225 mark.
Receive Sensitivity ....−46 dbm accoustically coupled.
Transmit Level ....−15 dbm nominal. Adjustable from −6 dbm to −20 dbm.
Receive Frequency Tolerance ...Frequency reference automatically adjusts to allow for operation between 1800Hz and 2400Hz.
Digital Data Interface ....EIA RS-232C or 20 mA current loop (receiver is optoisolated and non-polar).
Power Requirements ....120 VAC, single phase, 10 Watts
Physical ....All components mount on a single 5" by 9" printed circuitboard. All components included.

Requires a VOM, Audio Oscillator, Frequency Counter and/or Oscilloscope to align.

The Original the 3rd Hand

$9.95 each



- Leaves two hands free for working
- Clamps on edge of bench, table or work bench
- Position board on angle or flat position for soldering or clipping
- Sturdy, aluminum construction for hobbyist, manufacturer or school rooms

DIGITAL STOPWATCH

- Bright 6 Digit LED Display
- Times to 59 minutes 59.59 seconds
- Crystal Controlled Time Base
- Three Stopwatches in One
  Times Single Event — Split & Taylor
- Size 4.5" x 2.15" x .90" (4½ ounces)
- Uses 3 Penlite Cells



Kit — $39.95
Assembled — $49.95
Heavy Duty Carry Case $5.95

Stop Watch Chip Only (7205) $19.95

IMC 3½ DIGIT DPM KIT



- New Bipolar Unit
- Auto Zeroing
- .5" LED
- Auto Polarity
- Low Power
- Single IC Unit

Model KB500 DPM Kit	**$49.00**
Model 311D-5C-5V Power Kit	**$17.50**

JE700 CLOCK

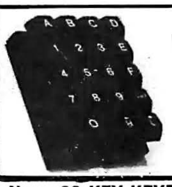


The JE700 is a low cost digital clock, but is a very high quality unit. The unit features a simulated walnut case with dimensions of 6" x 2½" x 1". It utilizes a MAN72 high brightness readout, and the MM5314 clock chip.

12 or 24 Hour
115 VAC

KIT ONLY **$16.95**

HEXADECIMAL ENCODER 19-KEY PAD



- 1 - 0
- ABCDEF
- Shift Key
- 2 Optional Keys

$10.95 each

New 63 KEY KEYBOARD $29.95

IN STOCK



This keyboard features 63 unencoded SPST keys, unattached to any kind of P.C.B. A very solid molded plastic 13" x 4" base suits most applications.

HD0165	Encoder Chip (encodes 16 Keys)	$7.95 ea.
AY-5-2376	Encoder Chip (encodes 88 Keys)	$14.95 ea.

JE803 PROBE



The Logic Probe is a unit which is for the most part indespensible in trouble shooting logic families TTL, DTL, RTL, CMOS. It derives the power it needs to operate directly off of the circuit under test, drawing a scant 10 mA max. It uses a MAN 3 readout to indicate any of the following states by these symbols (HI) - 1 (LOW) - 0 (PULSE) - P. The Probe can detect high frequency pulses to 45 MHz. It can't be used at MOS levels or circuit damage will result.

$9.95 Per Kit

printed circuit board

T²L 5V 1A Supply

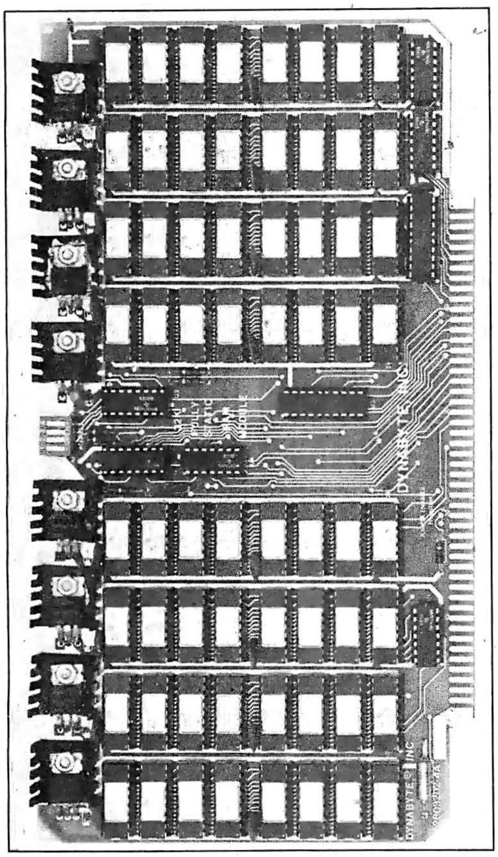


This is a standard TTL power supply using the well known LM309K regulator IC to provide a solid 1 AMP of current at 5 volts. We try to make things easy for you by providing everything you need in one package, including the hardware for only **$9.95 Per Kit**

Circle 61 on inquiry card.

What's New?

Static Programmable Memories from Dynabyte



Two fully static programmable memory modules for the Altair (S-100) bus are now available from Dynabyte Inc with access times of either 450 or 250 ns. The 250 ns mode is compatible with 4 MHz Z-80 processors.

Like the company's 16 K dynamic programmable memory module, both modules are completely assembled, tested, burned in and guaranteed for one year. They feature bank select, which allows up to eight separate banks (of up to 64 K each) to reside in the same system. The module may be addressed in four separate 4 K blocks along 4 K boundaries. Each of these 4 K blocks may be individually write protected. If an attempt is made to write into a protected block, an audible alarm will be activated and a visual indicator will be displayed for several seconds. The 32 K static module offers 4 K boundary addressing, complete buffering and conservative thermal design.

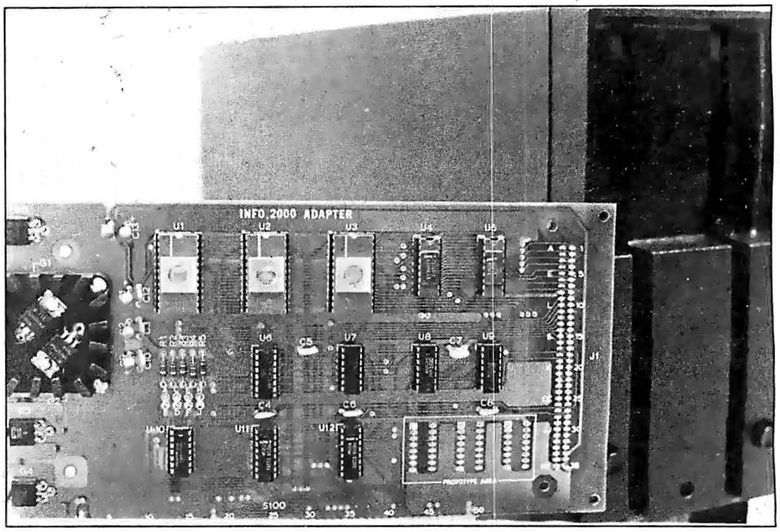
Suggested retail prices for the new modules are: Model 1645 (16 K, 450 ns): $525; Model 1625 (16 K, 250 ns): $555; Model 3245 (32 K, 450 ns): $925; Model 3225 (32 K, 250 ns): $995. Dynabyte products are available in retail computer stores. For more product information, contact Mike Watts or Rick Mehrlich, Dynabyte Inc, 4020 Fabian, Palo Alto CA 94303, (415) 494-7817.■

Circle 571 on inquiry card.

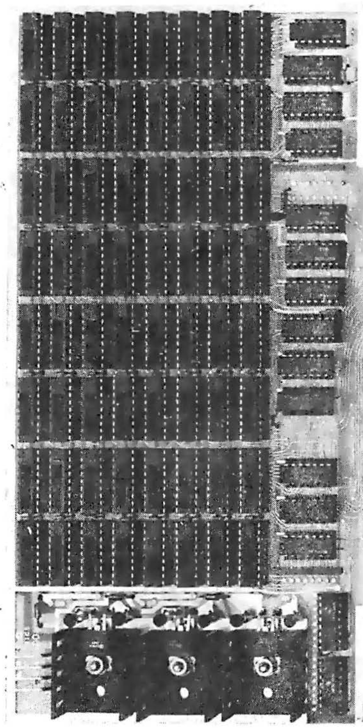
Intelligent Disk System

This dual floppy disk drive, intelligent controller and bus adapter package features an integral 8080 microprocessor and a complete repertoire of file management commands. The adapters interface the PerSci Model 277 disk drive and Model 1070 controller to either an Altair (S-100) compatible bus or a Digital Group bus. The adapter boards include sockets for 3 K of EROM and 1 K of programmable memory, which are designed to hold a disk operating system (DOS). Two versions of the DOS, one for Z-80 based Altair (S-100) bus computers and one for Z-80 based Digital Group computers, are available on appropriate memory chips (2708s and 2114s). The DOS permits the use of Technical Design Labs Z-80 software with the PerSci disk. TDL software distributed under license includes 8 K and 12 K BASICs, FORTRAN, and a text editor and word processor. The entire package including dual disk drive, controller, adapter and DOS for either bus, and all cables and connectors is priced at $2485. The DOS on memory chips alone is $180, and the Altair (S-100) adapter is $120 in kit form and $195 assembled and tested from Info 2000, 4901 Tara Ter, Culver City CA 90230, (213) 559-7121.■

Circle 573 on inquiry card.



Artec Electronics Introduces 32 K Byte Expandable Memory Board



Artec Electronics Inc has introduced a 32 K byte static programmable memory board in modular form designed for the Altair (S-100) bus.

Designated the 32K-100, the board is speed compatible with Zilog Z-80 based systems. The basic board with all support circuits, power regulator, 8 K bytes of memory parts and assembly manual sells for $290. An additional 8 K bytes of static memory chips cost $255 each, and a full 32 K memory board sells for $1055.

The 32K-100 requires a single +8 V 3 A power supply; access time of the direct memory accessible (DMA) compatible board is 250 ns. DMA compatibility allows users to access memory directly without going through the central processing unit (CPU) on the microprocessor board.

The 32 K board, fully buffered on all address and data lines, also features battery backup to allow operation at reduced power consumption, and a "bank select" provision so users can select the blocks, or banks, of memory they want to address. Contact Artec Electronics at 605 Old County Rd, San Carlos CA 94070, (415) 592-2740.■

Circle 572 on inquiry card.

NLS MS-15 MINISCOPE $289.00 NLS MS-15 MINISCOPE $289.00 NLS MS-15 MINISCOPE $289.00 NLS MS-15 MINISCOPE $289.00 NLS MS-15 MINISCOPE $289.00 NLS MS-15 MINISCOPE $289.00 NLS MS-15 MINISCOPE $289.00

Vector

8800V

Universal Microcomputer/processor plugboard, use with S-100 bus. Complete with heat sink & hardware. 5.3" x 10" x 1/16"

1-4	5-9	10-24
$19.95	$17.95	$15.96

8801-1

Same as 8800V except plain; less power buses & heat sink.

1-4	5-9	10-24
$14.95	$13.46	$11.96

3662 6.5" x 4.5" $7.65
3662-2 9.6" x 4.5" $11.45
P pattern plugboards for IC's Epoxy Glass 1/16" 44 pin con. spaced .156

Vector

R644 P.C. receptacle 22/44 cont .156 ctrs pierced solder eyelets tails gold $4.49
R644-3 P.C. receptacle 22/44 .156 ctrs Wire Wrap tails gold $3.45

Bus P.C. Edge Connectors S-100

R681 DIP solder tails on .140" spaced rows for ALTAIR mother boards. Fits .062 dia. holes $7.35
R681-1 .025 sq. 3 wrap length posts (.62" long) on .250 spaced rows. gold $5.00
R681-2 .025 sq. 1 wrap length posts (.22" long) on .250 spaced rows for wire wrapping or DIP solder for IMSAI mother boards. gold $5.65
R681-3 pierced solder eyelet tails. gold $7.35

NEW VOLKSMETERS!

With LCD Display—
Excellent Readability in Direct Sunlight!

LM-300
Full three digits
$99.50*

LM-350
3½ digits
$125.00*

FEATURES

- Measures DC volts, AC volts, ohms and current.
- Automatic polarity, decimal and overload indication.
- No zero adjustment and no full scale ohms adjust.
- Large LCD display for easy reading without interpolation.
- Size: 1.9" H x 2.7" W x 4.0" D.
- Parts and labor guaranteed for one year.

Standard AA-size batteries provide up to 20 hours of operation.
Rechargeable NiCad batteries and charger unit available as optional equipment.
*Batteries not included.

3690-12

Card Extender has 100 contacts — 50 per side on .125 centers — Attached connector — is compatible with S-100 Bus Systems $25.00

3690 6.5" 22/44 pin .156 ctrs. Extenders $12.00

.8" LED ALARM CLOCK

12 hr. LED Alarm Clock uses 3½ digit .8" LED Display with AM/PM indicators and colons. Direct drive, PIN to PIN interface with S1998A I.C. Just add switches, AC Supply, Alarm. Display and I.C. only.

$7.95 or 2/$15.00

8803

MOTHER BOARD FOR S100 BUS MICRO-COMPUTERS

- Kit includes 12 tantalum capacitors for +5, +12, −12 buses and insulated mounting spacers
- Wiring side shown. Component side bare epoxy glass with white markings for component locations
- G10 epoxy glass board with 2 ounce copper, solder plated and .038 diameter holes for leads
- Solder mask with solder windows on etched circuits to avoid accidental short circuits
- Mounts 11 receptacles with 100 contacts (2 rows) on .125 centers with .250 row spacing. Vector part number R681-2, or mounts 10 receptacles plus interconnections to smaller mother board for expansion
- Includes etched circuits and instructions for option of active, pull up, or floating terminations
- Large buses: +5V and GND (10 AMPS), ±12V or 16V (7 AMPS). Current ratings are per MIL-STD-275 with 10°C rise
- Fits in Vector pax enclosures
- Fits in IMSAI 8080 microcomputer as expander board

Price: $29.50

LIQUID CRYSTAL DIGITAL CLOCK-CALENDAR

SPECIAL

- For Auto, Home, Office
- Small in size (2x2¾x½)
- Push button for seconds release for date.
- Clocks mount anywhere with either 3M double-sided tape or VELCRO, included.
- 2 MODELS AVAILABLE: LCD-101, portable model runs on self-contained batteries for better than a year. LCD-102, runs on 12 Volt system and is backlighted.
- LCD-101 or LCD-102 your choice $33.95
- Clear desk stand for $2.00

WRAP POST

for .042 dia. holes (all boards on this page)
T-44 pkg 100 $2.28
T-44 pkg 1000 $14.00
A-13 hand installing tool $2.80

Vector

MS-15 MINISCOPE $289

With Rechargeable Batteries & Charger Unit

- 15 megahertz bandwidth.
- External and internal trigger.
- Time base — 1 microsec. to 0.5 Sec/div - 21 settings ± 3%.
- Battery or line operation.
- Automatic and line sync modes.
- Power consumption < 15 watts.
- Vertical Gain — 10 mV/div - 12 settings ± 3%.
- Viewing area 1.1" x 1.35".
- Case size 2.7" H x 6.4" W x 7.5" D. 3 pounds.
- Parts & Labor guaranteed 1 year.
- Probe $24.50
- Leather carrying case $20.00

PROBE 1¢ with the purchase of SCOPE

P1-VPK $7.95 or 2/15.00

DIRECT POSITIVE PHOTO-RESIST Ethed Circuit Kit

Close out from famous Manufacturer

Everything you need to make printed circuits without a darkroom.
- Single and double sided pre-sensitized positive printed circuit boards.
- Artwork pads, tape, IC's, trans. connectors, mylar, plus MORE
- Developer
- Developing/etching tray
- Etchant
- Extra materials available
- Repeatability. Make 1 or 100

14 & 16 PIN 3 LEVEL WIRE WRAP SOCKETS

14-T3 100 for $30.00
16-T3 100 for $30.00
50 of ea. for $32.00

MICRO-KLIP

for .042 dia. holes (all boards on this page)
T42-1 pkg. 100 $1.50
T42-1 pkg. 1000 $11.00
P-149 hand installing tool $2.03

SALE

SC-5 With Rechargeable Batteries & Charger Unit $79 ~~$99~~

FM-7 With Rechargeable Batteries & Charger Unit $168 ~~$185~~

Features include: • By using the new NLS SC-5 Prescaler, the range of the FM-7 Frequency Meter, which is 10 Hz to 60 MHz, may be extended to 512 MHz (the upper VHF & UHF frequency bands). • The FM-7 utilizes an LED readout, providing 7-digit resolution. • The FM-7 can be calibrated to an accuracy of 0.00001%. • The SC-5 is accurate to one part per million. • Each unit has 30 millivolts sensitivity. • Dimensions of each are 1.9" H x 2.7" W x 3.9" D. • The units may be obtained separately or as a "Frequency Duo". • Parts & Labor guaranteed 1 year.
Tilt stand option $3.50
Leather case $16.00

Joypot
100 K
$4.95
Buy 3 Get 1 FREE

2708
8K 450 ns
EPROM
FACTORY PRIME
1-9 $13.00
10-24 $12.50
25+ Call for Price

All-Circuit Evaluator for fast, solderless, plug-in circuit building and testing

Just plug in any components with leads to .032" dia. Interconnect with solid wire up to 20 ga. Assembled models too!

ACE Model 236 •

1/16 Vector BOARD

.042 dia holes on 0.1 spacing for IC's

Phenolic PART NO.	SIZE	PRICE
64P44-062XXP	4.5 x 6.5"	$1.49
169P44-062XXP	4.5 x 17"	$3.51
Epoxy Glass PART NO.	**SIZE**	**PRICE**
64P44-062	4.5 x 6.5"	$1.70
84P44-062	4.5 x 8.5"	$2.10
169P44-062	4.5 x 17"	$4.30
169P84-062	8.5 x 17"	$6.39

2102L1
450ns
RAM
Low Power—High Speed

8-24	$1.50
25-99	$1.40
100-249	$1.25
250 +	$1.19

3 LEVEL GOLD WIRE WRAP SOCKETS

	1-24	25-49	50-99
8 pin	.47	.42	.37
10 pin	.45	.41	.37
14 pin	.39	.38	.37
16 pin	.43	.42	.40
18 pin	.75	.68	.62
20 pin	.84	.77	.71
22 pin	1.00	.97	.95
24 pin	1.00	.94	.75
28 pin	1.09	.98	.84
36 pin	1.59	1.45	1.30
40 pin	1.49	1.39	1.29

Price Breakthrough:
MA1003 CAR CLOCK
$17.95
Bright Green Fluorescent Display Crystal Time Base Assembled, just add switches and 12 VDC.

73 BYTE RE KB

$5 Value **Free** $5 Value

Just send or mention this COUPON and MAGAZINE and receive with your order — DIP PROJECT BOARDS — assorted sizes and types, epoxy glass, prepunched and copperclad Boards.
part no PIVA $5.00

SPECIAL
14CS2 100 for $14.00
16CS2 100 for $16.00
14 pin CS2 10 for $2.00
16 pin CS2 8 for $2.00
These low cost DIP sockets will accept both standard width plugs and chips. For use with chips, the sockets offer a low profile height of only .125" above the board. These sockets are end stackable.

3682 9.6" x 4.5" $10.97
3682-2 6.5" x 4.5" $9.81
Hi-Density Dual-In-Line Plugboard for Wire Wrap with Power & Grd. Bus Epoxy Glass 1/16" 44 pin con. spaced .156

3677 9.6" x 4.5" **$10.90**
3677-2 6.5" x 4.5" **$9.74**
Gen. Purpose D.I.P. Boards with Bus Pattern for Solder or Wire Wrap. Epoxy Glass 1/16" 44 pin con. spaced .156

Perfectly balanced, fluorescent lighting with precision magnifier lens. For prof'l, techn'l & hobbist. Has die cast protective shade, inst. start 3 diopter lens 42" reach
with T-9 fluorescent lamp required
colors Gray or Black
$44.95

LEDU
MG 10A
List $72.00

PRIORITY ONE ELECTRONICS

10031W Woodley Ave. Sepulveda CA. 91343

Terms: VISA, MC, BAC, check, Money Order, C.O.D., U.S. Funds Only. CA residents add 6% sales tax. Minimum order $10.00. Orders less than $75.00 include 10% shipping and handling; excess refunded. Just in case . . . please include your phone no. Good thru June 1978

"Sorry, no over the counter sales"
phone orders welcome (213) 893-8202

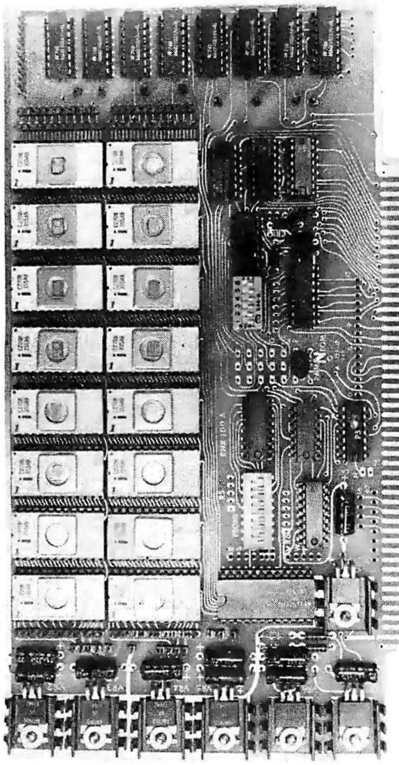
Send for our latest brochure.

OEM and Institutional inquiries invited.

Circle 90 on inquiry card.

What's New?

RAM-N-ROM from Szerlip



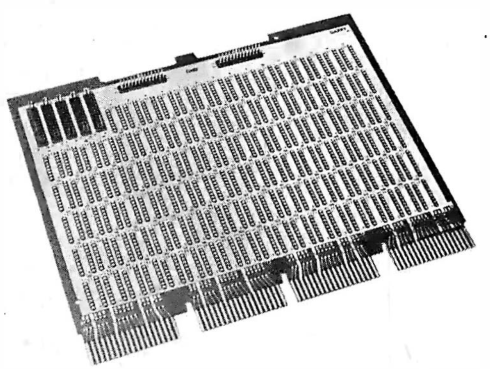
Szerlip Enterprises has introduced the RAM-N-ROM board, which operates on the Altair (S-100) bus and can be wired to accept several kinds of erasable read only memory (EROM). There are sockets for 16 EROMs and 1 K of volatile memory on this board. According to Szerlip, the new memory board is compatible with the following EROM parts: 1702A, 2704, 2708, 2716, 5204, and 6834. The EROM segment has its own switch for address select and control of up to four 8080 wait states. The volatile memory scratchpad also has its own switch for address select independent of the EROM.

The board has seven voltage regulators. Three regulators are dedicated for each group of eight EROMs. One separate 5 V regulator is used for all other logic including the volatile memory.

The RAM-N-ROM board has circuits that permit a power on jump if desired. The kit comes complete with sockets for all the integrated circuits and all the materials required including a manual (EROMs are not included). The RNR-100 sells for $117 in kit form and $168 assembled from Szerlip Enterprises, 1414 W 259 St, Harbor City CA 90710.■

Circle 586 on inquiry card.

Wire Wrapping Boards for LSI-11



The CIP4 and CIP4/11 universal wire wrapping boards plug into the Digital Equipment Corp standard "Omnibus" and "Q-Bus" backplanes, and provide 32 columns of 60 low profile socket terminals per column with alternate rows of ground and power terminals. The boards will accommodate up to 110 16 pin sockets or an equivalent in other sizes and are priced from $1.50 to $2 per chip position, from Garry Manufacturing Co, 1010 Jersey Av, New Brunswick NJ 08902, (201) 545-2424.■

Circle 587 on inquiry card.

You'll Have A Devil of a Good Time

A booklet entitled *The Devil's Dungeon,* and subtitled *An Adult Fantasy in BASIC* written by Dr C William Engel is now being marketed by Engel Enterprises, POB 16612, Tampa FL 33687. *The Devil's Dungeon* is a member of a class of games which involve various activities in a simulated labyrinth. In this case, the object is to retrieve simulated gold from a maze in an occasionally active volcano complete with monsters, demons and poisonous gas. The cover letter accompanying the copy we received credits inspiration for the program to simulation games such as "Dungeons and Dragons" which are typically done without computers.

The program is about 120 lines long, and is written in a fairly typical extended BASIC with multiple statements per line. The documentation includes a complete flowchart of the game with line numbers referencing the program listing, several pages of instructions in the use of the game, a list of the principle variables of the program and their uses in the program, and two lists of suggested modifications which the user may wish to consider.

The Devil's Dungeon is a 14 page booklet in a GBC binding, available from Engel Enterprises for $3.50.■

Circle 588 on inquiry card.

Accounting System in BASIC

A Comprehensive Accounting System in BASIC by Dr John Edwards contains a BASIC source program listing which includes sections on accounts receivable, accounts payable, merchandise inventory, fixed assets inventory, payroll, financial reporting, and check registers. A special section of the book and program listing is provided to help generate the initial database required by the other programs. The programs are disk file interactive and are said to comprise an entire business accounting system. Floppy disks containing versions of the programs for the Alpha Microsystems, Altair, and Poly 88 computers are planned for later release. The book is priced at $149.95, COD orders only, from Microcomputer Business Systems Inc, 1776 Plaza, 1776 E Jefferson St, Rockville MD 20852, (301) 468-0455.■

Circle 589 on inquiry card.

Full Scale Database Management System

Micro-SEED, a rich implementation of the April 1971 report from the Data Base Task Group of CODASYL, is said to be the first full scale database management system to operate on a microcomputer. It is compatible with SEED, a system available on the IBM 370, DECsystem 10 and 20 and other large computers. The package includes a Data Definition Language (DDL) which checks and compiles the data definition into a schema table, Data Manipulation Language (DML) subroutines which can be called from FORTRAN or assembly language programs to retrieve and update the database, and a database initialization program (DBINIT). Micro-SEED runs on the TDL Xitan Z-80 computers and requires the standard disk system configuration plus an additional 48 K bytes of memory. A user's manual is supplied with the package, along with three months of maintenance. Developed by International Data Base Systems Inc, Micro-SEED is sold for $1250 by Technical Design Labs Inc, Research Park, Bldg, H, 1101 State Rd, Princeton NJ 08540, (609) 921-0321.■

Circle 590 on inquiry card.

Word Processor in BASIC

IDSWORD1 is a word processing package designed to run under MITS Disk Extended BASIC. Some of its functions include line and global editing, merging files, moving words or blocks of text, printing with right justification, and production of form letters or mailing labels. The package consists of several programs loaded from disk under the control of a "menu" program, enabling the system to run on a computer with 28 K bytes of memory. The system is offered with documentation on a diskette for $250, from Interactive Data Systems, POB 290, Owings Mills MD 21117, (301) 486-6945.■

Circle 592 on inquiry card.

S.D. COMPUTER PRODUCTS AN EMPIRE IND. CO.
P.O. BOX 28810B DALLAS, TEXAS 75228

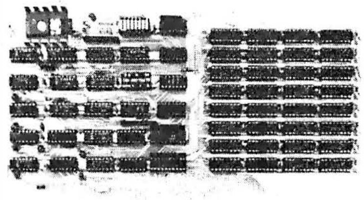
64K FOR $995.00

At last! The popular Expandoram is available in a 16k multiple version. Similar to our 32k Expandoram, the new Super Expandoram is offered in 16k, 32k; 48k and 64k. Low power devices mean the very lowest power consumption. Allow 3-4 weeks for delivery.

16K — $281.00	48K — $757.00
32K — $519.00	64K — $995.00

32K FOR $475 EXPANDORAM KIT 24K FOR $367.00

MEMORY CAPACITY
MEMORY ADDRESSING
MEMORY WRITE PROTECTION
8K, 16K, 24K, 32K using Mostek MK4115 with 8K boundaries and protection. Utilizes DIP switches. PC board comes with sockets for 32K operation. Orders now being accepted. Allow 6 to 8 weeks for delivery.



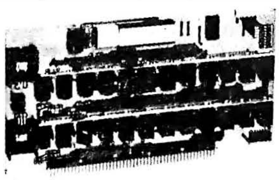
INTERFACE CAPABILITY
Control, data and address inputs utilizes low power Schottky devices.
POWER REQUIREMENTS
+8VDC 400MA DC
+18VDC 400MA DC
—18VDC 30MA DC
on board regulation is provided. On board (invisible) refresh is provided with no wait states or cycle stealing required.
MEMORY ACCESS TIME IS 375ns.
Memory Cycle Time is 500ns.

Buy an S100 compatible 8K Ram Board and upgrade the same board to a maximum of 32K in steps of 8K at your option by merely purchasing more ram chips from S.D. Sales! At a guaranteed price — Look at the features we have built into the board.

16K FOR $259.00 8K FOR $151.00

Z-80 CPU BOARD KIT — $139.

CHECK THE ADVANCED FEATURES OF OUR Z—80 CPU BOARD: Expanded set of 158 instructions, 8080A software capability, operation from a single 5VDC power supply; always stops on an M1 state, true sync generated on card (a real plus feature!), dynamic refresh and NMI available, either 2MHZ or 4MHZ operation, quality double sided plated through PC board; parts plus sockets priced for all IC's. *Add $10 extra for Z—80A chip which allows 4MHZ operation. **Z—80 chip with Manual** — 29 95



S.D. SALES NEW EXPANDABLE EPROM BOARD

16K or 32K EPROM **$49.95 w/out EPROM**
Allows you to use either 2708's for 16K of Eprom or 2716's for 32K of Eprom.
KIT FEATURES:

1. All address lines & data lines buffered.
2. Quality plated through P.C. Board, including solder mask and silk screen.
3. Selectable wait states.
4. On board regulation provided.
5. All sockets provided w/board.

WE CAN SUPPLY 450ns 2708's AT $11.95 WHEN PURCHASED WITH BOARD.

4K LOW POWER RAM KIT

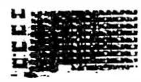
Fully Buffered — on board regulated — reduced power consumption utilizing low power 21L02 — 1 500ns RAMS — Sockets provided for all IC's. Quality plated through PC board. *Add $10. for 250ns RAM operation.



The Whole Works - $79.95

8K LOW POWER RAM — $159.95

Fully assembled and tested. Not a kit. Imsai — Altair — S-100 Buss compatible, uses low power static 21L02-500ns fully buffered on board regulated, quality plated through PC board, including solder mask. 8 pos. dip switches for address select.



250 ns Operation $189.95

6 DIGIT ALARM CLOCK KIT

Features: Litronix dual 1/2" displays, Mostek 50250 super clock chip, single I.C. segment driver, SCR digit drivers. Kit includes all necessary parts (except case). Xfmr optional. Eliminate the hassle.
AC XFMR — $1.50 Case $3.50 **$12.95**

NEW FROM S.D. "VERSAFLOPPY"™ KIT

THE VERSATILE FLOPPY DISK CONTROLLER

ONLY $149.00

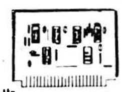
Features: IBM 3740 Soft Sectored Compatible. S-100 BNS Compatible for Z-80 or 8080. Controls up to 4 Drives (single or double sided). Directly controls the following drives:

1. Shugart SA400/450 Mini Floppy.
2. Shugart SA800/850 Standard Floppy.
3. PERSCI 70 and 277.
4. MFE 700/750.
5. CDC 9404/9406.

34 Pin Connector for Mini Floppy. 50 Pin Connector for Standard Floppy. Operates with modified CP/M operating system and C-Basic Compiler.
The new "Versafloppy" from S.D. Computer Products provides complete control for many of the available Floppy Disk Drives, Both Mini and Full Size. At the heart of "Versafloppy" is the powerful Western Digital FD1771B-1 Single Density Controller Chip. This allows a great flexibility via Control Software. Listings for Control Software are ncluded in the price.

FD 1771B-1 CHIP ALONE $39.95

Low Cost Cassette Interface Kit



Features: Play and record K.C. Standard 2400/1200 Hz tapes, 300 Baud, TTL I/O Compatible, Phase Lock Loop, Both 22 Pin Connector and 8 Pin Molex Connector. Comes partially assembled. Oscillator and phase lock loop pre-tuned to K.C. Standard. Selector switch sends cassette data or auxiliary input data to microprocessor. LED indicates logic 1 level.

$19.95

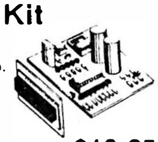
Bowmar 4 Digit LED Readout Array Full ½" Litronix Jumbo Dual Digit LED Displays

4 JUMBO .50" DIGITS ON ONE STICK!
WITH COLONS & AM/PM INDICATOR
$3.95

DL 722 - C.C.	DL 728 - C.C.
DL 721 8 C.A.	DL 727 - C.A.
99c	$1.2

Jumbo LED Car Clock Kit

FEATURES:
A. Bowmar Jumbo .5 inch LED array.
B. MOSTEK — 50250 — Super clock chip.
C. On board precision crystal time base.
D. 12 or 24 hour Real Time format.
E. Perfect for cars, boats, vans, etc.
F. PC board and all parts (less case) inc.
Alarm option — $1.50
AC XFMR — $1.50



$16.95

RAMS

21L02 - 500NS	8/11 50
21L02 - 250NS	8/15 95
2114 — 4K	14 95
1101A — 256	8/$4 00
1103 — 1K	35
MK 4115 - 8K	19 45
74S 200 - 256	3 95

CPU's

Z—80 includes manual	29 95
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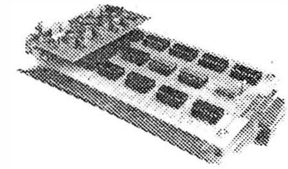
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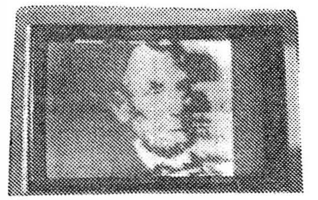
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"Brains" Top January BOMB

The results of the January 1978 BOMB tally were about as certain biased observers might have expected: Part 1 of Ernie Kent's "The Brains of Men and Machines" (page 11) was first place in the reader poll, with a total score 2.8 standard deviations above the mean of 13 articles. Prof Kent will receive a $100 bonus. Second place and a $50 bonus go to Peter Jennings' "The Second World Computer Chess Championships" (page 108) which had a score 0.6 standard deviations above the mean. The January poll standard deviation was 21% of the mean. ■

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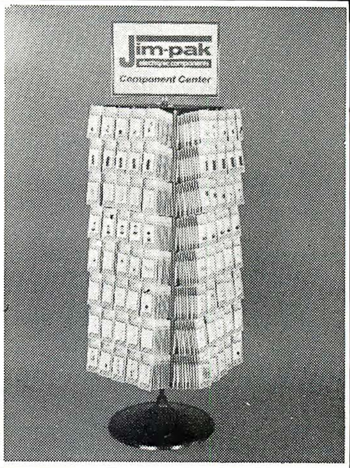
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Raleigh — *Byte Shop of Raleigh*
OHIO
Bucyrus — *Mead Electronics*
Cincinnati — *Digital Design*
Dayton — *Altair Computer Center*
Reynoldsburg — *Universal Amateur Radio*
Steubenville — *Hosfelt Electronics*
OKLAHOMA
Guymon — *Sound Service*
Oklahoma City — *Bits, Bytes & Micros*
OREGON
Beaverton — *Altair Computer Center*
Coos Bay — *Herrick Electronix*
Ontario — *Miller Electronics*
PANAMA
Panama City — *Sonitel, S.A.*
PENNSYLVANIA
Hershey — *Microcomputer Systems Inc.*
Murraysville — *Computer Workshop of Pittsburgh*
RHODE ISLAND
Cranston — *Jabbour Electronics City*
Pawtucket — *Jabbour Electronics City*
SINGAPORE — *Inter-Trade (PTE) Ltd.*
SOUTH CAROLINA
No. Charleston — *Technical Services Inc.*
TENNESSEE
Knoxville — *Byte Shop*
Memphis — *Sere-Rose & Spencer Electronics*
Oak Ridge — *Computer Denn*
TEXAS
Dallas — *Computer Shops Inc.*
Houston — *Altair Computer Center*
Houston — *Interactive Computers*
San Antonio — *Sherman Electronics Supply*
VIRGINIA
Alexandria — *Computer Hardware Store*
Alexandria — *Computers Plus*
Charlottesville — *Lafayette Electronics*
Richmond — *Computers-To-Go*
Springfield — *Computer Workshop of North Virginia*
Virginia Beach — *Heathkit Electronics Center*
WASHINGTON
Bellevue — *Altair Computer Center*
Longview — *Progress Electronics*
Pasco — *Riverview Electronics*
Seattle — *Empire Electronics*
Spokane — *Personal Computers*
WEST VIRGINIA
Morgantown — *The Computer Corner*
Morgantown — *Electro Distributing Co.*